MOTIVATING TEACHER AND STUDENT ENGAGEMENT WITH THE ENVIRONMENT THROUGH RENEWABLE ENERGY EDUCATION

A Dissertation
Presented to the Faculty of the Graduate School
of Cornell University
In Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy

by
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January 2017

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Cornell University 2017

Environmental and energy education is focused on fostering environmental behavior. This study investigates empirically if education leads to changes in environmental attitudes and subsequent environmentally significant behavior (ESB). The study contextualizes teachers' and students' motivation to engage in ESB within an environmental educational training framework. The results of structured questionnaires administered in Northeast, Mid-Atlantic, and Midwestern K-12 schools (n=214 for teachers and n=1498 for students) reveal that environmental attitudes are not a good predictor of teaching behavior but they do predict students' intent towards ESB. Teachers' energy attitudes are a better predictor in motivating them to teach while students are most responsive to their affective attitudes. The study finds that education does not play a significant role in changing environmental or energy attitudes of teachers and students. The study also advances a methodological tool for data collection that can expand the reach of evaluation instruments and measure learning across formal and informal audiences. It highlights how interactional technology can be readily utilized for future research and outreach in classrooms, nature learning centers, professional training programs, and museums. Overall, the work advances social-psychological understanding of how adults and youth respond to educational programming. It highlights the need to go beyond the cognitive shifts in affecting behavior. Curriculum based on environment might be necessary but is often

not sufficient for changing environmental values. Finally, information and knowledge acquired must motivate the teachers' and students' desire and ability to conscientiously act, wherever necessary.

BIOGRAPHICAL SKETCH

Dr. Patel was born and raised in Gujarat, India. The youngest of three children, he spent bulk of his childhood exploring farms and nature. Nirav earned a Bachelor of Science degree in the field of Botany and minored in Geology, Zoology, and Chemistry from the University of Pune. He has a Master of Science in Horticulture from Gujarat University before joining Cornell University for his doctorate. At Cornell, he has been actively involved with teaching various courses at Cornell. He has served as a visiting lecturer and served as an instructor for the biology cluster program. He has also worked as a teaching fellow at the Center for Teaching Excellence (CTE) for training fellow graduate students and a research fellow at the Center for the Integration of Research, Teaching, and Learning (CU-CIRTL). He has been recognized several times with teaching award(s) for the important contribution made towards the core biology instructional program at Cornell University.

I dedicate this to my countless students and teachers, who I have encountered on this journey, collectively they have influenced and motivated my work, and they continue to inspire me.

ACKNOWLEDGMENTS

I would like to thank all the student and teacher participants of this study for making this research possible. I am extremely grateful to my mentor and advisor *Dr. Richard C. Stedman*, who has offered a valuable guiding principle- "*No one wakes up in the morning and says I will be a bad human being today*". I have nurtured this powerful thought since the day he mentioned it to me and it has served me well. Without Dr. Stedman's steady hand none of this would have been accomplished. *Dr. Shorna B. Allred* has been remarkable with her guidance and dedication towards my growth as a researcher. Dr. *Corrine J. Rutzke* has been the rock solid support of my graduate life and without whose help, I would not have been able to drive 18,987 miles to collect research data. *Dr. Timothy J. Fahey* has always asked the right questions so that I can find the right answers and last but not the least *Dr. Travis Park* who has spent countless hours guiding and directing on what to expect when you visit K-12 institutions. I would also like to thank my research unit, *Human Dimensions Research Unit (HDRU)* members. Lastly, I do not think much of this would have happened without Dr. Sharon Mier and Dr. Stephane Corgie both of whom have kept me in check, when I needed it the most. My parents Usha and Sanat as well as Daksha and Kanti have been the silent but the steady supporters who have guided me to do what is necessary, and have taught me there is one thing that comes above everything else and that is 'work'. I thank you all of you for your never-ending support and faith in my pursuits.

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CHAPTER 1:

INTRODUCTION

1-1.1 Problem statement

The production and use of energy are inextricably linked to environmental, social, and economic issues. Energy conservation (i.e., reduced energy consumption) is an appropriate behavioral response to address climate change. Adapting to climate change and the inherent need for mitigation will depend greatly on behavioral choices and lifestyle preferences (Intergovernmental Panel on Climate Change, 2014). Managing human behavior becomes important, because the sheer volume of energy consumption and growth can overtake gains in technical efficiency (energy-efficient appliances, optimized energy distribution networks, energy insulation (Csutora, 2012; Midden, Kaiser, and McCalley, 2007). Researchers use a multitude of terms to describe these behaviors that either protect or enhance the environment, such as environmentally responsible behavior, pro-environmental behavior, or environmentally concerned behaviors or "environmentally significant behaviors" (Stern, 2000). My work will use this latter term. Environmentally significant behaviors (ESB) are defined primarily by their impacts:

"*the extent to which it changes the availability of materials or energy from the environment or alters the structure and dynamics of ecosystems or the biosphere itself*" (p. 408, Stern, 2000, also see Stern, 1997).

This research focused on ESB as it relates to teaching and learning about sustainable energy choices and the environment. Teaching and learning both rely on the premise that through education, direct or indirect actions can lead ultimately to a sustainable use of natural resources such as energy, which in turn can promote the health of the environment (Sivek and Hungerford, 1990; Stern, 2000). Education shapes behavioral choices by providing tools that can contribute to an individual's awareness. But education is only successful with a concurrent change of attitude that leads to ESB. Heberlein (2012) has termed this as "cognitive fix"-presenting information or educating people, and then relying on them to change their behavior. Energy education relies on informing the public and affecting behaviors such as energy use and conservation.

I investigated how ESB are influenced and motivated by education, i.e. how education motivates a teacher to teach and a student to learn about energy and environment. Specifically, I assessed the strength and limitation of training in energy and environmental education (EEE) to influence pro-environmental attitudes within adults (educators) and youth (K-12 students). I examined whether educational efforts must precede changes in educators' and students' pro-environmental behavior. I evaluated the effect of an energy-based, environmental education program focused on sustainability across Northeast, Mid-Atlantic, and Midwestern schools. I investigated and tested empirically the effects of formal EEE on environmental norms and subsequent environmental behavior. I assessed if adults and youth make pro-environmental decisions when they received necessary EEE. I also presented evidence about whether knowledge in itself leads to a motivation to engage in ESB. Lastly, across K-12 institutions, I have identified the prevailing cognitive processes and motivators that are impacted by EEE.

1-1.2 Environment and energy education

Science educators initiated the study of energy education in the mid-1970s (Morrisey and Barrow, 1984), during the Iran oil embargo, which resulted in high petroleum costs and volatility in supply of energy. The mid-1970s saw heightened energy and environmental awareness that resulted in corresponding legislation (the National Environmental Policy Act of 1970, The Clean Air Act of 1970, Emergency Petroleum Allocation Act of 1973, Emergency Highway Energy Conservation Act of 1974, Energy Policy and Conservation Act of 1975) the creation of the Department of Energy in 1977 and the formation of the Environmental Protection Agency (EPA) in 1970. The period of 1970-78 essentially gave rise to two distinct but collateral educational movements: environmental and energy education. Although both stemmed from the energy crisis, they differed in their targets. Energy education dealt primarily with establishing literacy about activities that were related to energy resources, production, distribution, and utilization (Coon and Bowman, 1978; Coon and Alexander, 1976); environmental education emerged in the 1960s to respond to emergent environmental crises, but only recently stressed the incorporation of pro-environmental values and behaviors within environmental training programs. According to the National Environmental Education Advisory Council (NEEAC), the United States (U.S.) leads the world in development of environmental education (EE) programs (NEEAC 2005).

Environmentalism also reached new heights during the energy crisis, which led to the adoption of a multidimensional definition of environmental education at the Tbilisi Inter-governmental Conference in Georgia, USSR in 1977 (UNESCO, 1980). The central tenet under the 1972 Stockholm declaration is "to protect and improve the environment for present and future generations"[1].

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[1] UN General Assembly, *United Nations Conference on the Human Environment*, 15 December 1972, A/RES/2994, available at: http://www.refworld.org/docid/3b00f1c840.html

Among the various strategies proposed within both the Tbilisi and Stockholm declarations was to utilize education as a tool to relate current findings of science and technology, such that it lead to an increased awareness and better understanding of environmental problems. The adopted declaration stated that environmental education should be provided to all ages through formal and informal education. An outcome of such environmental education programs would be for the individual to gain an understanding of current environmental problems, and to impart skills that would emphasize protection of the environment under an ethical framework that would lead to an increased sense of environmental commitment. The Tbilisi declaration presented five fundamental categories of environmental education for social groups and individuals:

1. awareness: Increasing the awareness towards environmental problems, and help acquire sensitivity towards the whole environment;
2. knowledge: To help in acquisition of basic knowledge as related to understanding of environment and its associated problems;
3. attitudes: To help gain a set of values and feelings of concern toward environment, and also channel such values to increase participation in environmental stewardship;
4. skills: To help gain skills that support in identifying and solving environmental problems;
5. participation: To engage them actively at all levels of rectifying environmental problem.

If we examine the primary fundamentals listed above, we find a schism: energy education is rooted in influencing energy conservation, whereas environmental education focuses on the effects of energy use on environment and the resultant environmental impacts. Energy conservation relies on modifying human behavior by incentivizing energy savings and the resultant economic benefits. But environmental education highlights the risk of energy depletion and environmental damage that is coupled with resource extraction and use. However, both rely on impacting action and associated benefits. Given this reliance, energy education programs were a natural fit within environmental education (Campbell, 1977). Energy education includes consumer behavior, K-12 energy education programs, workforce development, and training programs for existing and emerging energy technologies. To develop increased energy literacy in citizens, Fowler (1976) specified key fundamentals that remain relevant:

1. understand the science and technology of energy and its influence on humans;
2. make informed and equitable judgments on emerging energy options;
3. adapt personal lifestyle commitments to changing energy situations;
4. be aware and prepared to participate in opportunities for establishing an energy policy; and
5. encourage energy conservation at the personal, local, state, and national levels.

1-1.3 Environment and energy education and STEM

Concerns over global climate change, environmental degradation, and dwindling nonrenewable energy resources have prompted the need for an effective renewable energy education (Thomas, Jennings, and Lloyd, 2008). Renewable energy education is typically integrated within Science, Technology, Engineering, and Math (STEM) teacher training programs. STEM training programs are focused on education and professional development for prospective or existing STEM teachers. There is a growing concern in the United States about whether we have a sufficient number of students and educators in STEM fields. This has led to a multitude of training and education programs earmarked through STEM appropriations. In fiscal years 2008-2012, $52.4 billion was appropriated under the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act of 2007 and 2010 (COMPETES 2007, 2010 Act, GAO, 2013). Specifically, in fiscal year 2010, 13 federal agencies invested over $3 billion in 209 programs that were designed to increase knowledge of STEM fields and attainment of STEM degrees (Scott, 2012) and energy-related knowledge (Curry, Ansolabehere, and Herzon, 2007; NEETF, 2002).

1-1.4 Environmental education and environmentally significant behavior

I utilize the term "Environmentally Significant Behavior", because it represents actions taken by persons or groups to reduce environmental problems to as great an extent as possible (Steg and Vlek, 2009; Lee et al., 2013). To mitigate negative environmental impacts, previous studies have focused on factors that affect an individual's ESB, such as environmental attitude (Kaiser et al., 1999), environmental values (Stern, Dietz, Abel, Guagnano, and Kalof, 1999), and environmental education (Hsu and Lu 2004). Environmental education work revolves around the four components of environmental literacy: knowledge, affect, cognitive skills, and behavior (Hollweg et al., 2011). Energy literacy has now expanded into topics such as: ecological knowledge, environmental attitudes and sensitivity, issue and action skills, and verbal and actual commitment to pro-environmental behavior (Hollweg et al., 2011; McBeth, Hungerford, Marcinkowski, Volk, and Meyers, 2008).

Much of the initial research in environmental education (especially in the United States) has focused on examining the effectiveness of directed, environmental educational activities in influencing ESB. This approach has contributed to thinking among environmental education practitioners who assume that there exists a linear relationship between knowledge, awareness, attitude, and pro-environmental behavior. Early models that characterized ESB assumed that knowledge and education led directly to a change in attitudes and, thereby, ESB were fostered and engaged (see for example Ramsey and Rickson, 1976). Some studies have cited evidence in favor of a linear relationship among education, attitudes, and ESB (Costanzo, Archer, Aronson, and Pettigrew, 1986; Dunlap, 1978; Murphy and Eisenberg, 2002; Ramsey and Rickson, 1976). However, most of the evidence has pointed to a complicated structure of education and attitudes that eventually *may* lead to ESB. Multiple studies have refuted linear, cause-and-effect models that linked knowledge and attitude to behavior (see for example Arbuthnot, 1977; Borden and Schettino, 1979; Newhouse, 1990; Sia, Hungerford, and Tomera, 1986), suggesting the assumed relationship above is neither as strong nor as simple as its advocates suggest.

Much research has measured environmental attitudes as predictors for ESB. Research, primarily from social psychology, has shown that environmental attitudes may not always predict ESB. Although people with strong environmental attitudes tend to act more pro-environmentally (Kollmuss and Agyeman, 2002; Maiteny, 2002; Chen et al., 2011; Fielding and Head, 2012), there is conflicting evidence on the impact of education on attitudes (Kolmuss and Agyeman, 2002). Information in itself does not result in behavioral changes (Schultz, 2002, Hungerford and Volk, 1990, Stern, 2000, Kollmuss and Agyeman, 2002). But not having relevant information is a deterrent in adopting new behavior (Schultz, 2002; Kaplan, 2000; DeYoung, 2000). Specifically, information and knowledge that are acquired by an individual must motivate the desire and ability to act conscientiously. Recent EE work is trying to focus on understanding the cognitive basis of individual's response to environmental issues (Wals, Brody, Dillon, and Stevenson, 2014). Thus, it is important to identify which cognitive processes and motivators are most impacted through education.

1-1.5 Theoretical basis and perspectives

Previous research has utilized the theory of reasoned action, theory of planned behavior, norm activation theory, and values-beliefs-norms theory to explain ESB. These studies have suggested that an individual's ESB is based on his/her reasoned choice, and the theory of reasoned action and the theory of planned behavior (TPB) have been applied to identify relationships between environmental attitude and behavior (Lee, 2007; Kaiser et al., 1999; Han et al., 2010). TPB is a modified version of the theory of reasoned action, both of which are used to predict behaviors from attitudes and to explain the nature of that relationship (Ajzen, 2002; Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975; Fishbein et al., 2001). Both theories highlight the importance of behavioral intent as the strongest predictor of behavior, and they are often used to identify if an intervention produces a desired behavioral impact. Education is a type of behavioral intervention and individuals are seen as "rational actors". Most individuals will make rational decisions that carefully weigh their choices based on their values, beliefs, and outcomes. This is especially true in a formal educational environment such as K-12 students and teachers, the target population for this study. Teachers and their students usually make optimal decisions after receiving necessary information through education in K-12 environment.

Fishbein and Ajzen's theory of planned behavior is based on the premise that people are essentially rational and, whenever possible, they will make systematic use of information available to them and are not “controlled by unconscious motives or overpowering desires”; neither is their behavior “capricious or thoughtless” (Ajzen and Fishbein, 1980). However, attitudes do not influence behavior directly, but they affect behavioral intention that may then lead to ESB. Thus, attitude is latent to the behavior being measured and behavioral intent is the most proximal predictor of behavior. It is influenced by attitude (favorable or unfavorable) towards the behavior, perceptions of the norms regarding the behavior (i.e., subjective norms), and the extent to which the behavior at hand is under her or his personal control i.e., perceived behavioral control (PBC) (Ajzen, 2002; Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975; Fishbein et al., 2001). PBC relates to an individual’s belief that their behavior will promote expected goals. Thereby, PBC becomes an additional determinant of intentions and behavior.

I utilized the theory of reasoned action for measuring teachers’ behavior towards teaching renewable energy, sustainability, and environment in their classrooms. Given that teachers are adults, they ought to have a measure of volitional control over the behavior of interest (i.e., teaching). However, for students, I utilized TPB, because it cannot be assumed that they are in control of their behavior (i.e., learning). Under such conditions where students have limited or no control of their learning environment, PBC is an important determinant of behavior in students (i.e., youth), because the extent to which some intentions can be carried out depends in part on the level of control an individual has or perceives to have on their behavior. The locus of control is a specific attitudinal variable that affects an individual’s behavior. It primarily measures an individual’s perceived control over various situational factors at play. It was first introduced by Rotter (1966) as part of social learning theory, which states that an individual’s behavior is determined by three equally interacting factors:

(1) psychological situation: the necessary cues that an individual accumulates that will affect 'value of reinforcement' and 'expectancy of reinforcement';

(2) value of reinforcement: any factor or set of factors that occur, such that its occurrence or direction affects the behavior; and

(3) expectancy of reinforcement: the probabilistic determination by an individual that a particular reinforcement will occur as a function of a specific behavior on their part.

Locus of control focuses on the perception of control; self-efficacy focuses on the perception of the ability to act competently and effectively (Strauser, 2002). Locus of control, in particular, is differentiated into two types (Lefcourt, 1992):

(1) Internal Locus of control: When an individual (i.e. internals) makes a determination that their behavior can be dictated by a set of factors that are all within their control and a belief in internal control. Internals believe they can control their external environments and these individuals perceive a strong link between their actions and consequences.

(2) External Locus of control: When an individual (i.e. externals) attributes their behavior as under the control of factors such as luck, chance, fate, control of others, or a complex set of factors, then these are deemed to be external or beyond an individual's degree of control. Externals perceive themselves in a passive role with regards to their external environment.

The internal and external control represent an individual's perception of whether they have the ability to bring about a change through their own behavior (Newhouse, 1991). People with a strong internal locus of control believe that their actions can bring about change. Such individuals are more likely to express their willingness to engage in an action. Locus of control indirectly could predetermine the formation of attitude, and the related attitudinal action and behavioral intent. Behavior at times might not be indicative of an attitude that is acted upon; for example, the adoption of renewable energy, such as solar panels, could purely be to offset costs and not for any environmental benefits *per se.* Therefore, locus of control and, specifically, control beliefs can serve as predictors of behavioral intent and action.

Control beliefs govern differential dispositional tendencies in individuals (i.e., individuals with varying belief exert differential control over their respective external environment). These beliefs apply to students and teachers across different age groups (Abel and Hayslip, 2001; Finn and Rock, 1997). Control beliefs reflect the information that people have in relation to the performance of a given behavior, but this information is often inaccurate and incomplete; beliefs may rest on faulty or irrational premises, be biased by self-serving motives like fear, anger, and other emotions, or otherwise fail to reflect reality. Even if inaccurate, biased, or otherwise irrational, our beliefs produce attitudes, intentions, and behaviors consistent with these beliefs (Geraerts et al., 2008). An individual that cares deeply about the environment and who is also already engaged in actions that protect or better the environment will need very little reinforcement to continue such behavior. However, another individual from a similar environment could exhibit a total lack of engagement towards the environment. Ajzen’s expanded behavior model, the Theory of Planned Behavior, uses the term “real or perceived ability” or “perceived behavioral control” to account for self-efficacy (Ajzen, 1991). I utilized this model for predicting students’ behavioral intent to learn about energy and environment. TPB and TRA emphasize the controlled aspects of information processing and decision-making by humans. Both theories concern is primarily with behaviors that are goal-directed and steered by conscious self-regulatory processes that operate within bounded rationality. Learning or teaching are examples of such behavior.

Much of the work on education has tried to improve cognitive skills and the measurement has focused primarily on cognitive tests and abilities. Cognitive skills are those that relate to memory, learning and retention abilities (Heckman, 2011). Yet, more recently there has been an increased emphasis on non-cognitive skills (Duckworth and Yeager, 2015; Heckman and Kautz, 2013), these skills are difficult to define but are often conceptualized within behavioral attributes such as self-esteem, locus of control and confidence (see Borghans, Duckworth, Heckman, and Ter Weel, 2008 for detailed discussion). Recent work has shown that non-cognitive skills are significant in affecting education outcomes as well as lifetime success (Heckman and Kautz, 2012). Furthermore, non-cognitive skills have been shown to be more malleable than cognitive skills (Cunha and Heckman, 2008). Thus, it is important to focus on assessing which of these skills (i.e. cognitive or non-cognitive) is more likely to cause a change in behavioral intent and action.

1-1.6 Limitations of using the TPB and RAA models

TPB is an influential model that has been used extensively in social psychology, and environmental behavior and attitudes. However, there are several limitations that need to be addressed.

(1) ***Assumption of rationality:*** The greatest and perhaps the most important limitation of TPB and RAA is the inherent assumption that people act rationally (Regis, 1990). Newer insights suggest that human cognition and motivation are not predicated solely on this traditional

view. We often make decisions that are not rational, and which are based on normative expectations, emotions, and snap judgments (Jaeger, Webler, Rosa, and Renn 2013; Kahneman, 2003; Dietz and Stern, 1995; Parks, Joireman, and Van Lange, 2013). TPB relies exclusively on rational reasoning, and it discounts unconscious determinants of behavior (Sheeran, Gollwitzer and Bargh, 2013). Furthermore, it fails to capture the role of emotions beyond the anticipated affective outcomes on behavior (Conner, Gaston, Sheeran, and Germain, 2013). The theory's exclusive focus on rational reasoning creates a gap between attitude and behavior. This gap occurs since individuals are limited by amount of information that is available to them at any given point. The argument against such a methodology is that much of the information is lost if attitudes are measured in a narrow and contrived manner, even if they correlate with behavior (Lehmann, 1999). Individuals are bounded by the cognitive limitation of their mind and time allocated to make a decision (i.e. bounded rationality needs to be factored into TPB).

(2) ***Attitude specificity:*** Bell et al. (1996) reported that attitude specificity, normative influences, and attitude accessibility confounded the attitude-behavior relationship. This suggests that positive attitudes towards environment do not always translate to positive environmental behavior. We now know that what many researchers describe as one construct (environmental attitude) is actually composed of two distinct attitudes (Kaiser, Hartig, Brügger, and Duvier 2011). The two attitudes are environmental protection and attitude towards nature (Kaiser, Brügger, Hartig, Bogner, and Gutscher, 2014). Most individuals report their concern for the environment in the form of environmental protection as the object; it includes individuals wanting to protect the environment and their need for

ecological management (Milfont and Duckitt, 2004). The second attitude (i.e., nature) is founded on the attitude that is related to the natural environment around us (Brugger, Kaiser, and Roczen, 2011). Given the correlated structure of attitudes on environmental protection and attitudes toward nature, there is some probability for both of these attitudes to occur concurrently. Recent work highlights and recognizes the heterogeneous nature of pro-environmental attitudes (Larson, Stedman, Cooper, & Decker, 2015; Lee, Kim, Kim, & Choi, 2014). According to Steg and Vlek (2009) participation in pro-environmental behavior is influenced social and structural factors. Hence, when attitudes are accompanied with such correlated structural problems, they lose accuracy in predicting the behavior that is being tested.

(3) ***Measurement issues:*** A study that examined the relationship between attitudes, subjective norms, and intentions to teach found that attitudinal measures do not adequately predict behavior among prospective elementary school teachers (Koballa, 1986). Koballa's work highlighted that intentions need to be coupled with subjective norms to predict behavior effectively. The findings showed that when attitudes and subjective norm were measured simultaneously then the correlation between attitude and behavioral intention increased, and it increased further when including subjective norm variables. Thus, the model is weakened when attitudes are not measured in a specific manner.

(4) ***Static view:*** TPB provides a static view of the motivational processes that underlay volitional behaviors, because of the situation-specific nature of its components. Behaviors are elastic and do not remain steady, but TPB assumes a static nature that discounts the evidence of current behavior on cognition and future behaviors (McEachan et al., 2011; Sutton, 1994).

(5) ***Past behavior:*** The impact of TPB is reduced substantially with the inclusion of past behavior in the model (Bagozzi, 1981; Bagozzi and Kimmel, 1995; Conner and Norman, 1996). These studies suggest that the theory is incomplete, and several authors have recommended that additional variables should be included in the theory to explain behavioral consistency further (Conner and Armitage, 1998).

(6) ***Long-range predictive validity:*** Prior work has suggested that behaviors operate within certain boundaries, outside of which there is a limitation on whether or not individuals can continue to engage in a certain behavior. Thus, multiple studies have questioned the long-range predictive validity of the model (Chatzisarantis and Biddle, 1998; Hagger, Chatzisarantis, Biddle, and Orbell, 2001). The predictability associated with TPB becomes weak when studies use longitudinal data. Behavioral predictions using TPB are valid if the participants are university students or under 'shortitudinal design' only (Sniehotta, Presseau, and Araújo-Soares 2014).

(7) ***Quasi-experimental evidence:*** TPB has been the dominant theory in use, yet surprisingly, most studies have not tested its validity under experimental conditions. A detailed meta-analysis of the use of TPB with intervention found insufficient evidence for the usefulness of the theory in predicting behavioral change (Hardeman, Johnston, Johnston, Bonetti, Wareham, and Kinmonth 2002). Hardeman and her colleagues found only 24 studies used TPB under experimental testing with intervention. Prior studies that have targeted one or all of the theory's predictors with interventions under a factorial experimental test have been unsuccessful in modifying the theoretical target variables (McCarty, 1981). Often when these

variables were targeted successfully, they did not result in behavioral change (Chatzisarantis and Hagger, 2005).

(8) ***Multiple constraints to behavior:*** TPB is not able to completely account for lack of engagement that stems from multiple constrains. These include external factors that impede behavior (Jensen 2002), contextual factors (Steg and Vlek 2009), subjective constrains (Tanner, 1999) such as psychological barriers (lack of motivation or inherent interest), and barriers (Kollmuss and Agyeman 2002).

Despite all these limitations, TPB has been shown to be effective in university and classroom settings. It has also been used to explain a variety of environmental behaviors, such as recycling (Kaiser and Gutscher, 2003), composting (Mannetti, Pierro, and Livi, 2004; Taylor and Todd, 1995), choice of travel mode (Bamberg, Ajzen, and Schmidt, 2003; Heath and Gifford, 2002), purchasing of energy efficient appliances (Harland et al., 1999), water conservation (Trumbo and O'Keefe, 2001), and generalized pro-environmental behavior (Kaiser, F. G., Wölfing, S., and Fuhrer, U., 1999). The theory has also been applied to a large variety of other contexts, such as driving (Parker 1992), health-related practices (Black and Babrow 1991), and sexual behavior (Boldero, Moore, and Rosenthal 1992).

1-1.7 STEM training education program

I will discuss environmental and energy behavior throughout the dissertation as impacted through a directed STEM training program that targeted teachers (grades 8-16, pre-service and in-service). The teachers were exposed to multi-disciplinary content that involved research-based training materials and lab activities. This research project collaborated with the Northeast

Bioenergy and BioProducts (NBB) Educational Program, which was funded through a USDA/NIFA grant. The overarching goal of the program was to utilize the community-university partnership to encourage more students to consider careers in math and science. The partner institutions, as part of the NBB education program, consisted of Cornell University as the lead institution, and included Boyce Thompson Institute in Ithaca, NY; Cornell University Biofuels Research Laboratory in Ithaca, NY and Cornell University NY Agricultural Experiment Station in Geneva, NY; Delaware State University in Dover, Delaware; The Ohio Bioproducts Innovation Center in Columbus, Ohio; Pace University Energy and Climate Center in White Plains, NY; Rochester Institute of Technology; University of Maryland, Eastern Shore; and the USDA NRCS Plant Materials Center in Big Flats, NY.

The emphasis at these training sites was to provide teachers with a systems perspective and learning-standard-ready teaching tools. During the training, the teachers took part in group-based activity that involved lab experiments and modules, which they later were given to tailor to their needs. Furthermore, they were given the most current information on topics such as biofuels, sustainability, systems thinking, and related policy issues. The program trained teachers by providing training tools and aids, which included seven classroom kits, a lab workbook that contained 20 activities that were aligned to Next Generation Science Standards, a companion Primer booklet, three teaching videos, a SmartBoard biobased ethanol curriculum, and a set of 20 PowerPoint files for teachers to use/edit to fit their classroom lesson plans in their own school district.

Educators from seven states participated in an in-service professional development program on teaching students about renewable energy, environment, and sustainability. The participants consisted of pre-service teaching, extension educators, college teachers, and K-12 educators. Most participants possessed substantial teaching experience and some knowledge of renewable energy systems. The three-week long program was called the Certified Master Teacher Trainers (CMTTs) program. In this program, the participants were trained at Cornell University in June 2012. CMTTs were provided training in the program's focus areas of sustainability, systems thinking, biomass, biopower, biofuels, bioheat, bioproducts, environment, and policy. A full suite of kits, engagement activities, power points, handouts, and videos were given to participants for their classrooms. The CMTTs then assisted site directors in training the one-week program for another subset of educators called the Master Teacher Trainers (MTs). The five one-week programs were held between July 16 and August 17. The sites for the 2012-13 education program year were:

1 Cornell University

2 Boyce Thompson Institute (BTI) for Plant Res, Cornell University.

3 Energy and Climate Center at Pace University Law School.

4 University of Maryland-Eastern Shore

5 Delaware State University.

6 Ohio Bioproducts Innovation Center, Ohio State University.

During the research implementation years (2012-13), diverse educators participated within the multiple states at the list of participating Universities mentioned earlier; this became the sample of teachers and students for the current study (Fig 1-1, next page)

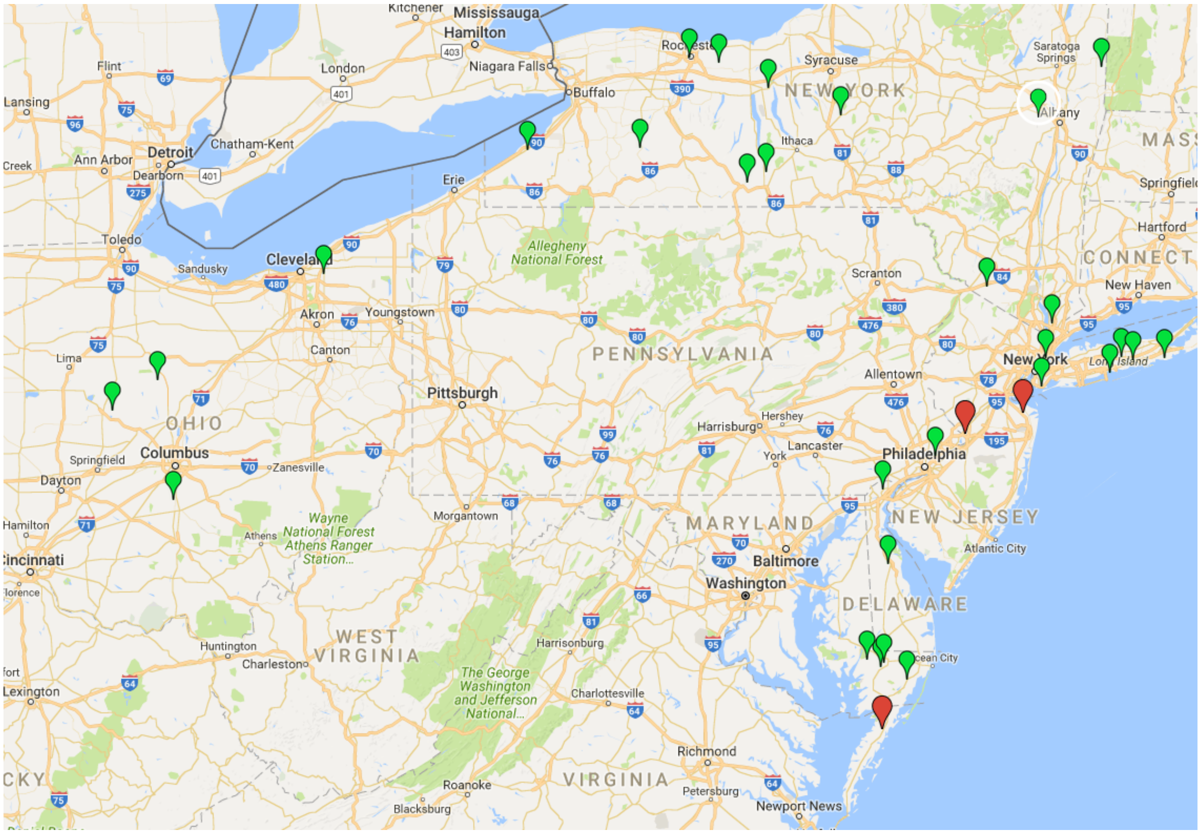

Figure 1-1: Location of participating high schools in the current project 2012-13

(Note: green pin indicates continued participation through the full academic year, red pins denote no participation after pre surveys of Sept-Oct, 2012 due to hurricane Sandy)

Institutional Review Board:

The project has obtained IRB review from Cornell University under the protocol ID #: 1105002254, titled “Educators' and Students' Perceptions of Attitudes towards Renewable Energy Systems (RES)”. The IRB staff reviewed the project and found it to qualify for an exemption from a full IRB Review according to paragraph #1, 2 of the Department of Health and Human Services Code of Federal Regulations 45 CFR 46.101(b). Similar exemptions were also obtained from Pace University, Delaware State University, University of Maryland at Eastern

Shore, and Ohio State University office of sponsored programs and/or Institutional review. Also, the stated schools (Fig 1, previous page) have corroborated these reviews and given approval for access to their facilities, including access to their students. Wherever it was deemed necessary by schools and the educators, parents of the students were notified of the survey date, time, and details through their teachers and principals.

1-1.8 Research goals and objectives

This research strives to improve our understanding of the role of education in influencing behavior, and the broader impacts that education may have in attitudes towards sustainability, energy, and the environment. Through this dissertation, I seek to untangle whether education on environment and energy generates a shift in environmental attitudes and results in ESB. The research is guided by the following overall objectives:

1. Establish comprehensive measurement tools for surveying in K-12 institutions.
    a. Assess the validity of measurement using Audience Response Systems (ARS).
    b. Conduct an equivalence testing between ARS and paper-and-pencil modes in collecting survey data.
2. Develop a valid and reliable quantitative, attitudinal survey on renewable energy that meets the following criteria:
    a. Is developed according to a social-cognitive model of human behavior (i.e. TPB);
    b. Can predict behavioral intentions of youth (i.e., students) and behavior of adults (i.e., teachers given the intervention of EEE);

c. Is based on established psychometric principles and established methodologies for creating valid, reliable written surveys in the educational and sociological sciences;

d. Is appropriate for diverse students and teachers in Northeast, Mid-Atlantic, and Midwestern K8-12 school districts, in terms of language, level of conceptual understanding, and appropriateness of topics;

e. Is convenient, easy, and suitable for classroom administration, and uses allocated class time;

f. Is comprehensive in nature, targets critical benchmarks that define environmental and energy behavior in terms of students' and teachers' broad knowledge and cognitive skills, affective aspects such attitudes and values, and behaviors.

3. Use the survey to improve our understanding of energy and environmental attitudes within a broad sample of K-12 students and teachers and to examine specifically the following questions, with or without the intervention of EEE:

   a. How do students and teachers perform, overall, on the instrument subscales: attitudes towards behavior; subjective injunctive norms and descriptive norms; behavioral intentions; perceived behavioral control; behavioral; normative; and control beliefs?

   b. Can we identify specific subscales that are more robust in explaining the full effect of the intervention within teacher and student samples?

   c. Are there meaningful and measurable effects of the intervention and do these effects differ between students and teachers?

The research described in this dissertation is presented in a series of papers that address different aspects of the research. *Chapter 2* provides background and a review of literature that is pertinent to the issues of response rates and the specific use of ARS in survey research. It highlights the efficacy of using ARS as a collection tool for survey data. It establishes the use of ARS (i.e., i-clickers) as a novel tool for mixed methods research that allows us to see the emergent relationships between human attitudes toward the environment and human behavior. Often, studies of environmental attitudes collect individual level data as outcome measures. To isolate the interaction of variables that describe the individuals and the groups relies heavily on statistical power. The analysis of such data requires robust sample sizes for each level. In this paper, I demonstrate how Audience Response Systems (ARS) could be used within youth populations as an effective tool to increase participation in surveys, and thus enhance statistical power. Furthermore, I confirm the equivalence of using ARS when compared with a paper-and-pencil, data collection mode within a youth population of ~1400 K-12 students across five states. I also show statistical equivalence with traditional methods, such as paper and pencil surveys. I highlight how ARS technology can be utilized as a mode of survey data collection, which maximizes efficiency of mass testing and ease of data collection within youth participants. Youth are able to integrate well with interactional technology and, thus, by extending the use of novel data collection techniques, I am able to further the needs of human dimensions research.

Chapter 3 describes the research study that involved teacher training and its effect on teachers' likelihood to teach sustainability and renewable energy in their classrooms. I showed that having prepared curricula and receiving formal training were not significant predictors of engagement with environmental topics within their teaching. My research showed that while an environment-oriented curriculum might be necessary, it was often not sufficient for imparting values and skills that engage K-12 classrooms. Across K-12 institutions, I found that there were prevailing cognitive processes and motivators that were not impacted by education alone. I found that environmental attitudes were not good predictors of teacher engagement in teaching renewable energy, sustainability, and environmental topics. However, teachers who have positive attitudes toward the topic of energy and teaching were more likely to teach the subject with or without training. I reported that the highest predictability is associated with age; teachers that are from baby boomer and generation ‘x’ had the highest probability of teaching when compared with millennial generation teachers. The training programs need to enable and motivate teachers’ desire and ability to act (i.e., teach) on the knowledge gained if they are to be successful.

In *Chapter 4*, I delineate the effect of education on behavioral intent of K-12 students to engage in ESB. Utilizing a quasi-experimental design, I show that providing education on renewable energy does not make students more likely to express an intent to undertake ESB when compared to that of control group of students without such an curriculum. This body of work adds evidence to newer insights that suggest that human cognition and motivation are not entirely rational and dependent on education. I show that social-psychological factors such as affective and environmental attitudes can act independently of education. Most interestingly, I show that environmental science classes are not the most conducive in affecting ESB in youth. Science and language classrooms better engage student behavioral intent towards ESB in the future. A second piece of findings from this work shows that environmental and anthropocentric attitudes tend to occur together and they, collectively with affective attitudes, inform and engage ESB in youth. I find that after affective attitudes, anthropocentric attitudes are the second largest predictors of students' behavioral intent towards ESB. This research advances our understanding of ESB and can provide useful input to environmental conservation programs. A cognitive understanding of nature might provide more suitable answers towards ESB than education alone.

References from each chapter are given after the chapters, as are the appendices, which provide supplementary information for each of the three research chapters.

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CHAPTER 2:

ASSESSING THE EQUIVALENCE OF AUDIENCE RESPONSE SYSTEMS AND THE PAPER-AND-PENCIL SURVEY MODE: EVIDENCE FROM A QUASI-EXPERIMENTAL STUDY OF K-12 STUDENTS

Abstract

This study examines whether audience response systems (ARS) can be used effectively to collect survey data within structured environments, compared to paper-and-pencil surveys. I analyze surveys that explore responses of students before and after receiving a renewable energy education curriculum across five U.S. states (DE, MD, NY, OH, and PA). Purposive sampling was utilized in a quasi-experimental study that resulted in students completing identical survey items using ARS and paper-and-pencil survey response modes (n=1498). I report quantitative equivalence at moderate and large effect sizes. Equivalence was also revealed using auxiliary tests (i.e., response rates, proportion of missing data) further indicated equivalent data. Overall, results indicated that both modes yield equivalent data, and support the use of ARS technology for survey data collection for youth participants. Potential benefits and limitations of the ARS mode suggested that ARS technology can be paired with other data collection methods to obtain higher response rate and increased engagement of students.

Key Words: Audience response system, Classroom Performance System, i-clickers, Survey instruments, Equivalence testing, Renewable energy education, Youth

2-1 Introduction

There is a vast body of social-psychological research addressing environmental behavior (e.g., Dietz and Stern, 2002; Heberlein, 2012; Schultz and Kaiser, 2012; Stern, 2011). Some of this work centers on youth population that involve K-12 students (Bamberg, 2003; Ewert and Baker, 2001; Liefländer and Bogner, 2014; Nisbet, Zelenski, and Murphy, 2008; Pe'er, Goldman, and Yavetz, 2007). Surveys are one important tool to assess attitudes, beliefs, and self reported behaviors relevant to the environment. Researchers have consistently relied on youth and in particular students in classroom environments for measuring environmental attitudes and related behavioral beliefs (Benckendorff, Moscardo, and Murphy, 2012; Copper, Poe, and Bateman, 2004; Hodgkinson and Innes, 2000; Kaiser, Hubner, and Bogner, 2005; Kortenkamp and Moore, 2006; Liu and Sibley, 2004; Mancha and Yoder, 2015; Snow, Allen, Jacovina, and McNamara, 2015; Vikan, Camino, Biaggio, and Nordvik, 2007). The youth survey data, however, raise important issues regarding self-report measures and the anonymity of respondents, as well as sample compositions (Ewert, Place, and Sibthorp, 2005; Evans, Brauchle, Haq, Stecker, and Wong, and Shapiro, 2007). Most K-12 educational research, particularly that funded by federal agencies, relies heavily on surveys to gather data on practices, curricula, attitudes and behaviors. A review of the 2010 National Center on Education Evaluation contracts (n=67) suggests that approximately 60% included surveys as a data source. A similar review of the 106 National Center for Education Research grants awarded by the Institute for Education Sciences in 2010 indicates that about half plan to collect data via survey methods.

In any survey-based data collection effort, accessing a representative sample and high response rates are crucial to data quality (Bloom, 1998). A higher response rate (RR) confers statistical power and enhances representativeness; it also augments greater credibility among key stakeholders within evaluation programs (Rogelberg and Stanton, 2007). Response rates can vary substantially based on mode of survey method. A review of the literature (see appendix A, Table 2-1) suggests that RRs vary widely depending on the data collection procedures employed. In general, electronic surveys have had lower RRs (Robson, de Wet, McKay, and Bowie, 2011, Scott, et al. 2011) and often lack a representative cross-section of the population (Jones, et al. 2008). Despite the importance of RR to the scientific validity of study findings, few studies have examined ways to maximize participation rates in youth surveys conducted via newer available technologies.

The influx of technology in education presents multiple opportunities for researchers using survey methods (Cobanoglu, Warde, and Moreo, 2001; Sills and Song, 2002). Technology in survey research has primarily been used to gather research participants, resulting in more diverse samples, limiting the costs of survey administration, and eliminating the need for data entry (Cantrell and Lupinacci, 2007; Gosling, Vazire, Srivastava, and John, 2004). The introduction of mobile phones, social networking, and e-mails has presented newer opportunities for collection of survey data (Couper, 2005; Madden, Lenhart, Duggan, Cortesi, and Gasser, 2013). If studies of youth are to increase, newer technological tools such as Audience Response Systems (ARS), and their wider adoption as a survey tool, needs to be evaluated along with other established methods.

2-1.1 *ARS in classroom use and data collection*

ARS are automated data gathering devices used to present questions, record responses, and provide feedback. Originally, ARS technology was conceived as a teaching tool. ARS were first utilized in classrooms at Stanford University in 1966 (Judson and Sawada, 2002) and have since become ubiquitous in classrooms (Abrahamson, 2006) to enhance student learning (Fies and Marshall, 2006). ARS allow anonymous responses, which removes conformity pressure that occurs when students are asked to participate by raising hands (Buhay, Best, and McGuire, 2010), thus greatly increasing student participation (Eggert, West, and Thomas, 2004; Stowell and Nelson, 2007). ARS further adds a “game approach” (Martyn, 2007) or an element of fun in classrooms (Hoffman and Goodwin, 2007), and interactive classrooms and, thereby, enhances students’ learning experience (Mazur, 1997). ARS also have the ability to process a large number of responses simultaneously, making them well suited for data collection.

Despite these advantages, ARS have rarely been used to collect data and limited research has examined their effectiveness as a data collection tool (Bunz, 2005). There have been nearly 300 articles evaluating the effectiveness of ARS on student learning and pedagogy[2]. Much of this work highlights the use of ARS for active learning in classrooms. Only a handful of studies have addressed the use of ARS to gather data (Draper, Cargill, and Cutts, 2002; Gamito, Burhansstipanov, Krebs, Bemis, and Bradley, 2005). Prior to this study limited studies have used ARS in acquiring large data set for research purposes (Bunz, 2005; Langley, Cleary, and Kostic, 2007; and McCarter and Caza, 2009; Miller and Hartung 2012). To our knowledge none of these studies or any other study thus far have compared ARS to other methods to test for equivalence within the same sample.

[2] For a detailed bibliography refer to- https://cft.vanderbilt.edu/docs/classroom-response-system-clickers-bibliography/

2-1.2 Why is equivalence important?

Equivalence testing allows determining whether multiple modes would yield equivalent data. Using different data collection methods may result in nonequivalence as can using one mode for validating measures and then utilizing such measures across other modes (Coons, Gwaltney, Hays, Lundy, Sloan, and Revicki, 2009; deLeeuw, Hox, and Dillman, 2008). Comparability between collection modes should not be assumed (Buchanan, 2003; Dolnicar, Laesser, and Matus, 2009). The primary issue is potential measurement biases between modes (Gwaltney, Shields, and Shiffman, 2008).

2-1.2.1 Types of equivalence: Three types of equivalence testing exist: qualitative, quantitative (Buchanan, 2007; Preckel and Thiemann, 2003) and auxiliary (Weingol, 2013). Qualitative equivalence refers to internal consistencies and scale intercorrelation comparisons (Meyerson and Tryon, 2003). Quantitative equivalence is measured via comparing mean scores and variances across modes. Weigold, Weingold, and Russell (2013) express auxiliary equivalence via response rates and response time, and missing items analysis.

2-1.2.2 Equivalent participant samples concerns: Concerns about equivalence have been documented widely in the literature comparing the paper and pencil mode to the web-based mode (Barak and Cohen, 2002; McDonald and Adam, 2003; Naus, Philipp, and Samsi, 2009; Shih and Fan, 2008; Whittier, Seeley, and St. Lawrence, 2004), However, these analyses have not been subjected to a formal test of equivalence to assess if there is non-equivalence in collected data. The main methodological issue associated with research on equivalence testing between modes is the potential for nonequivalent samples under differing conditions (Epstein, Klinkenberg, Wiley, and McKinley, 2001; Buchanan, 2003). Methodological concerns such as differences in recruitment procedure, participant self-selection to conditions, and inconsistencies in the data collection procedures need to be addressed to obtain an equivalent sample for equivalence testing and survey structure procedures (see, Weigold et al., 2013).

2-1.3 Tests of equivalence—previous work

Equivalence testing was devised for biomedical purposes to assess comparability between pharmaceutical products (Schuirmann, 1987). Since then, equivalence tests have been used in medicine (Munk, Hwang and Brown, 2000), psychology (Rogers, Howard and Vessey, 1993), pharmaceutical science (Kringle, Khan-Malek, Snikeris, Munden, Agut, and Bauer, 2001; Tubert-Bitter, Manfredi, Lellouch, and Bégaud, 2000), process engineering (Stein and Doganaksoy, 2000; Richter and Richter, 2002), chemistry (Roy, 1997), and environmental science (McBride, 1998). Weber and Popova (2012) adapted tests of equivalence in the fields of communication and psychology to create meta-analyses.

A common error among many tests of equivalence is to use null hypothesis significance testing (NHST) to establish equivalence. The comparison of two modes using a t-test simply denotes how dissimilar the two sample means are to each other. Equivalence testing should not be confused with the more familiar method of significance testing when comparing two means. The two approaches share an overall strategy, where a researcher assumes a “null hypothesis” and tests whether the data provides sufficient evidence to reject it, given which, concludes that the “alternative hypothesis” is true. Equivalence testing and significance testing for differences between two means differ in how the null hypothesis is stated. Equivalence tests are “inferential statistics designed to provide evidence for a null hypothesis” (Levine, Weber, Park, and Hullett, 2008, p. 199).

2-1.4 Formal equivalence testing procedure

The paired-samples equivalence procedure of Weber and Popova (2012) allows comparing ARS and paper-and-pencil mode for identical survey items. The paired-samples equivalence test has not been used previously in comparing survey methods and specifically in comparing ARS data collection. Hence, the Weber and Popova (2012) dependent sample equivalence test is used to measure equivalence of survey item responses between paper-and-pencil and ARS modes.

Given that the objective of the research study is to test the similarity of ARS measurement in relation to paper-and-pencil, it is the equivalence between ARS and the paper-and-pencil mode that needs verification. The following research question and hypotheses were developed:

Research Question and Hypotheses

RQ: Does the reliability and equivalence of the survey instrument differ across two discrete modes (ARS and paper-and-pencil) of data collection?

H1: Response rates are equivalent for students who receive ARS and paper-and-pencil surveys.

H2: The proportion of missing data is equivalent for students who receive ARS and paper-and-pencil surveys.

H3: Reliability of response is equivalent for students who receive ARS and paper-and-pencil surveys.

2-2 Methods

2-2.1 Description of research project and survey

A survey was conducted following the training of educators by a consortium of nine institutions of higher learning in the United States. The consortium provides professional development workshops on renewable energy to Science, Technology, Engineering and Math (STEM) teachers, grades 6 through undergraduate college. This study evaluates attitudes towards renewable energy education, and the variables that affect them.

A survey tool was developed and administered to equivalent groups of students: 1) students of educators who attended an energy workshop and 2) students of educators who did not attend the energy workshop. Participants in this study were middle school (MS) and high school (HS) students in five U.S. states (Delaware, Maryland, Ohio, New York, and Pennsylvania). The surveys were administered through the use of ARS and paper-and-pencil modes. I compare ARS and paper-and-pencil modes within these equivalent student groups. The two groups were assessed at the beginning and end of the academic year (September-October, 2012; April-May, 2013).

2-2.2 Survey measures

The survey items explored student attitudes and beliefs toward renewable energy/sustainability as well as their perceptions about their own and others' (teachers, friends, family, and parents) learning about renewable energy and sustainability. The items were developed based on the theory of reasoned action (Ajzen, 1991; Fishbein and Ajzen, 2010). From a larger survey instrument, 13 items were used to test equivalence (Appendix A). These items addressed behavioral belief; normative belief; control belief; attitudes towards renewable energy; subjective norm; perceived behavioral control; students' behavioral intention; behavior and specific external variables. These items were repeated across both modes (ARS and paper-and-pencil) within the same student groups. Identical recruitment procedures were followed with consistent data collection procedures across classrooms.

2-2.3 Validation checks

2-2.3.1 Acquiescence, ordinal bias, and inverted scale Items: Measurement error due to acquiescence is common in attitudinal and personality measurement (Krosnick, 1999). The tendency of respondents to choose responses by their location or position in survey can lead to ordinal biases. Three questions (items 5,6, and 7) were evaluated using a contradictory inverted scale between ARS and paper measure item (i.e., if Likert scale 1 referred to strongly disagree on paper-and-pencil then for that same question, Likert scale 1 on the ARS survey referred to strongly agree). This allowed checking for ordinal bias tendency as well as any response bias tendency, which is the tendency to answer questions in the direction of social desirability as perceived by the participants (DeMaio, 1984).

2-2.2.2 Question-order effect: There is always the possibility that question order affects response patterns. Often respondents are known to truncate memory searches upon having obtained enough information to answer. The most accessible information is often drawn upon to answer questions (Sudman, Bardburn, Schwartz, 1996). Typically, general questions are more susceptible to order effect than specific content questions (Schuman and Presser, 1981). As such, general questions were asked in beginning and one specific question appeared after 50% of survey responses on the pre and post survey repeat measures. Two specific questions (item 8 and 4) appeared later in survey such that respondents are not reliant on prior responses and more importantly to check if ARS offers equivalence for the full duration of survey protocol.

2-2.4 Audience response system units

I used ARS technology called iclicker™ (for additional description see Barber and Njus 2007; D'Arcy, Eastburn, and Mullally, 2007). The device consists of an instructor remote and student remotes (Fig. 2-2a). The remotes work in conjunction with a radio frequency operated base (Fig. 2-2b). The iclicker itself is a hand-held, five-option remote that allows students to choose on a Likert scale a value of A through E. The individual student remote contains a unique alphanumeric code that identifies the clicker. The iclicker™ base collects all the responses and unique identification number. Data are stored on a USB, which is easily transferrable to computers and downloaded to Excel or HTML formats.

Figure 2-2a: Instructor Remote is shown with base frequency (middle) and wireless electronic student remote (left)
Figure 2-2b: iclicker™ base (right) ©iclicker™ technology

2-2.4 Survey procedure:

2-2.4.1 Oral consent procedure and IRB: Students were given an oral consent form at beginning of the survey that was approved by XXX University IRB (Protocol ID# 1105002254). This indicated to students that their participation was voluntary and they could stop at answering at any point. It was stressed to the students that their participation or lack of participation would not affect their academic standing, and participating in the survey was not part of their grade. Only two students out of 1587 (0.1%) refused to participate, and they were excused by their teacher to work on other schoolwork.

2-2.4.2 Controlling satisficing: The anonymous function of clickers was turned on so students could not see any polling results. This reduced the tendency to exhibit satisficing behavior or conformity. The real-time feature of ARS allowed the researcher to note instantly the results. Respondents that engaged in selecting same choice for >90% of all ARS responses or skipped parts of the paper-and-pencil survey were marked as an invalid respondent. The >90% threshold was established for this study to ensure that we do not include respondents that are strongly satisificing. Invalid responses were removed during analysis from both ARS and paper-and-pencil surveys. Very few (17, or 1.1%) of the participants were removed because of this procedural check.

2-2.4.3 *Procedure for equivalent participant samples:* Only students that completed both the beginning and end of school year surveys were used for equivalent sample analysis. To avoid potential confounding factors, all students were recruited using the same oral consent procedure (see, section 2-2.4.1). To avoid participants' self-select conditions (i.e., ARS or paper-and-pencil), all students who took the ARS survey were also administered paper-and-pencil surveys.

To avoid procedural differences between conditions in which some of the participants have contact with an experimenter and others do not, the same experimenter was present in both conditions.

2-2.4.4 ARS versus paper-and-pencil survey procedure: First, the surveys were administered through the use of iclicker™ technology and paper-and-pencil survey followed. As is true for other ARSs, iclicker™ was designed to have an interface with an AV presentation such as Microsoft Office PowerPoint. Power Point was used to present the slides for every survey item. The researcher waited for students to answer each question before moving on to the next slide. The students were allowed to finish the survey in class, and students that needed additional time were given additional class time to finish the paper-and-pencil survey. The researcher collected these surveys at the end of the day and matched them with the associated clicker id. Finally, paper-and-pencil surveys were matched with ARS surveys based on clicker ID numbers. Only students that completed both ARS and paper surveys were used for the overall analysis.

2-2.5 Data analysis

Auxiliary and quantitative equivalence were assessed. Auxiliary equivalence investigates reliability using descriptive statistics for repeat survey items between ARS and paper-and-pencil. It then examines response rates and missing values using Wilcoxon signed rank testing. Quantitative equivalence is assessed using paired-samples equivalence testing procedure (Weber and Popova, 2012).

Effect size measures the magnitude of a difference of treatment or how different two groups are from one another (Cooper, 2010; Salkind, 2008). To compute an effect size, the mean difference is divided by a pooled standard deviation (Coladarci, Cobb, Minium, and Clarke, 2008). Weber and Popova (2012), suggest that in the absence of established criteria for effect size on testing equivalence, one option is to utilize Cohen's (1992) conservative guidelines for effect size interpretation at the 0.10, 0.30, and 0.50 Δ levels. A dependent sample equivalence test between paper-and-pencil and ARS repeat items on the survey was performed and equivalence within the study was interpreted at the moderate effect size (Δ=0.30).

Lastly, to answer specifically how well ARS performed across a range of contexts, the threshold value of equivalence was calculated. The threshold Δ represents a difference that is not large enough to have any significant effects. Threshold determination allows for meaningful interpretation of what is the largest difference between the means of the population that would be meaningless (Ball, Cribbie, and Steele, 2013), i.e., the point at was the ARS mode is no longer equivalent to the paper-and-pencil mode.

2-3 Results

2-3.1 RQ: Does the reliability and equivalence of the survey instrument differ across two discrete modes (ARS and paper-and-pencil) of data collection?

Summary result: The auxiliary equivalence as indicated by reliability analysis showed no difference between the paper-and-pencil mode and ARS mode. However, I report non-equivalence between the modes using missing value analysis. A comparison of quantitative equivalence (i.e., mean equivalence and dependent sample equivalence test) showed equivalence at moderate and large effect sizes (Δ =0.30, 0.50), but not at small effect size (Δ =0.10). Overall, reliability and equivalence testing indicated that ARS mode was equivalent to paper-and-pencil mode as a means of collecting youth survey responses.

2-3.2 Auxiliary equivalence

H1: Response rates are equivalent for students who receive ARS and paper-and-pencil surveys

The survey sample consisted of 1,587 students and resulted in 1,498 total completions. The same student was surveyed twice and thus, I defined completions as the same student that completed repeat items in ARS and paper-and-pencil surveys which was administered at beginning and end of the school year, respectively. Using the American Association for Public Opinion Research (AAPOR formula), a response rate of 95.5%[3] was obtained.

Table 2-1: Post-survey missing values between paper-and-pencil and ARS.

Post Survey Item #	**Paper**		**ARS**	
	Valid	**Missing**	**Valid**	**Missing**
1	1462	36	1479	19
2	1460	38	1479	19
3	1461	37	1479	19
4	1431	67	1479	19
5	1461	37	1479	19

H2: The proportion of missing data is equivalent for students between ARS and paper-and-

[3] *AAPOR Outcome Response Rate 4 Calculator* (Version 3.1 November, 2010) is based on American Association for Public Opinion Research standard definitions.

pencil surveys.

Missing value analysis was conducted on survey items 1 through 5. I report differences in missing values across modes (Table 2-1). Since the missing values for repeat survey items across ARS or paper-and-pencil were not normally distributed across students, the missing values for five survey items (9-13) were subjected to Wilcoxon signed rank test (appendix B, Table 1). The differences are significant (Wilcoxon signed rank test, $P < 0.01$, two-tailed) between the average numbers of missing values across modes for these five items. Due to unequal number of questions within the two modes, I assessed total percent of missing values across mode. Here again, the percent missing values were not normally distributed and were subjected to a Wilcoxon signed rank test (appendix B, Table 2-2). Differences in the percent missing values across ARS and paper-and-pencil mode are significant (Wilcoxon signed rank test, $P < 0.005$, two-tailed): ARS had fewer missing values (1.2%) than paper-and-pencil (2.9%).

H3: Reliability of response is equivalent for students who receive ARS and paper-and-pencil surveys.

Minimal differences are reported (Table 2-2, next page) in mean and SD across items using ARS and paper-and-pencil modes. The differences ranged from 0.00 (item 2) to 0.32 (item 6) as is reported in Table 2-2. The average difference of mean between ARS and paper-and-pencil across all items was 0.14 indicating little evidence of differing values across modes.

Table 2-2: Mean equivalence of repeat items (paper-and-pencil and ARS)

Survey Item #	Paper			ARS		
	Valid (N)	Mean	SD	Valid (N)	Mean	SD
1	1498	1.76	0.82	1498	1.73	0.86
2	1498	1.84	0.88	1498	1.84	0.87
3	1498	2.21	0.90	1498	2.29	0.93
4	1498	1.45	0.70	1498	1.47	0.64
5+	1498	4.19	1.13	1498	4.18	1.09
6+	1498	2.49	1.19	1498	2.81	1.28
7+	1498	3.50	1.01	1498	2.90	1.09
8	1498	2.21	1.30	1498	2.27	1.49
9	1462	2.99	1.22	1479	3.08	1.38
10	1460	3.40	1.18	1479	3.66	1.26
11	1461	2.39	1.23	1479	2.35	1.32
12	1431	3.82	1.08	1479	4.06	1.15
13	1461	3.18	1.20	1479	3.30	1.30

+Inverted scale comparisons; item 1-8 pre-survey; 9-13 post-survey

2-3.3 Quantitative Equivalence Testing

2-3.3.1 Equivalence testing using paired sample t-test: Using NHST (i.e., paired sample t-test), I report significant differences ($p<0.05$; Table 2-3, following page) within 8 of the 13 items tested for equivalency.

Table 2-3: Paired sample t-tests for repeat items (paper-and-pencil and ARS)

Item #	Mean	Std. Deviation	95% Confidence interval of the difference		t	df	Sig. (2-tailed)
			Lower	Upper			
1	0.04	0.51	0.01	0.06	2.87	1497	0.00*
2	0.00	0.85	-0.04	0.04	0.03	1497	0.98
3	-0.08	0.91	-0.12	-0.03	-3.31	1497	0.00*
4	-0.03	0.88	-0.07	0.02	-1.26	1497	0.21
5+	0.00	1.39	-0.07	0.07	0.04	1497	0.97
6+	0.37	2.56	0.24	0.50	5.65	1497	0.00*
7+	0.60	1.76	0.51	0.69	13.26	1497	0.00*
8	-0.06	1.22	-0.12	0.00	-1.91	1497	0.06
9	-0.09	1.06	-0.14	-0.03	-3.10	1442	0.00*
10	-0.25	1.13	-0.31	-0.19	-8.41	1440	0.00*
11	0.05	1.23	-0.02	0.11	1.39	1441	0.16
12	-0.24	1.30	-0.31	-0.17	-6.91	1411	0.00*
13	-0.11	1.03	-0.16	-0.05	-3.92	1441	0.00*

*Indicates statistical significance of $p < .05$ +Inverted scale comparisons;

2-3.3.2 Threshold of equivalence testing using paired sample t-test: Since item # 2, 4, 5, 8, and 11, were not significant under NHST, specific threshold for items were calculated. These range from delta (Δ) 0.017 to 0.330 (See, Table 2-4, next page).

Table 2-4: Threshold delta for equivalence for paper-and-pencil and ARS survey modes

Survey Item #	Threshold Delta
1	0.103
2	0.080
3	0.113
4	0.110
5^{+}	0.071
6^{+}	0.231
7^{+}	0.330
8	0.140
9	0.110
10	0.231
11	0.110
12	0.200
13	0.129

$^{+}$Inverted scale comparisons

2-3.3.3 Equivalence testing using dependent paired-samples equivalence test: I also performed a Weber and Popova (2012) dependent paired-samples equivalence test of students to check for equivalence of the two modes. This equivalence test showed similarity (p<0.05,Table 2-5, next page) between modes large effect size or .50 delta level.

Table 2-5: Paired-samples equivalence procedure repeat items (paper-and-pencil and ARS)

Survey Item No.	t	df	p, two-tailed given specified Delta (Δ)		
			.10	.30	.50
1	2.87	1497	.064	.000*	.000*
2	.03	1497	.000*	.000*	.000*
3	-3.31	1497	.139	.000*	.000*
4	-1.26	1497	.001*	.000*	.000*
5^{+}	.04	1497	.000*	.000*	.000*
6^{+}	-8.65	1497	1.00	.000*	.000*
7^{+}	13.26	1497	1.00	.395	.000*
8	-1.91	1497	.006*	.000*	.000*
9	-3.10	1442	.114	.000*	.000*
10	-8.41	1440	1.000	.000*	.000*
11	1.39	1441	.002*	.000*	.000*
12	-6.91	1411	.996	.000*	.000*
13	-3.92	1441	.348	.000*	.000*

*Indicates statistical significance of $p < .05$; item 1-8 first sampling; 9-13 second sampling

At the .30 delta level, or moderate effect size, the responses between modes were also similar ($p<0.05$, Table 2-5) for all items except for item 7 ($p>0.05$, $p=0.395$, Table 2-5). Specifically, for items 1, 3, 6, 7, 9,10, 12, and 13 were found to be not significant ($p>0.05$, Table 2-5) within the .10 delta level, or small effect size. This is in agreement with NHST that detects these small differences (Table 2-3). Finally, items 2, 4, 5, 8, and 11 were significant ($p<0.05$, Table 2-5) at all effect sizes.

2-4 Discussion

2-4.1 *Auxiliary equivalence*

2-4.1.1. Response rates: I report a similar response rate (>95%) to previous literature (see appendix A, Table 1) for ARS surveys on youth audiences. All students completed both survey modes in classrooms; I attribute the high response rate to the structured environment that is offered in a classroom. Specifically, the long-term panel study reported an average classroom response rate of 82.6% from 1975-2012 (Bachman, Johnston, and O'Malley. 2014). ARS further lends itself as an interactional tool that increases engagement (Blasco-Arcas, Buil, Hernández-Ortega, and Sese, 2013), which leads to high response rates in student populations.

2-4.1.2 Missing data: Using ARS resulted in fewer missing values than paper-and-pencil (table 2-1). I believe that the use of ARS in a classroom environment led to social conformity to participate (Brady, Seli, and Rosenthal, 2013; Stowell, Oldham, Bennett, 2010). However, this conformity did not lead to invalid or unreliable responses (Table 2-2). The live display of the total participants that respond to each survey item on screen created an environment where participants were engaged. ARS can serve as an effective tool when seeking anonymous answers and can serve to reduce participant embarrassment and increase participation. The use of ARS mode first and then paper-and-pencil mode could have also resulted in lower response rate across ARS mode. Future research needs to conduct a randomized implementation of mode across classes that verify the response rates further.

Overall, the amount of missing data was trivial across all students and conditions, with slightly more missing data with the paper-and-pencil mode. However, the paper-and-pencil mode resulted in significantly greater missing values than the ARS (Appendix B, Table 2-1and 2-2). This may indicate that youth participants favor ARS over paper-and-pencil. In most situations, the presence of small amounts of missing data is not a particularly large issue, although paper-and-pencil formats may be less appropriate than the ARS when it is essential that participants complete all items. ARS mode offers greater completion rates given real time data collection with live audiences and youth participants.

2-4.1.3 Reliability of response: The high completion rate (>95%) and low missing values in ARS (1.2%) can be attributed to convenience of responding along with the structured audience present in such classroom settings. Lower response rates occur if surveys are inconvenient for participants, for example, by not having a stamped return envelope or other conveniences for responding (Armstrong and Luske, 1987). Woo, Kim, and Couper (2014) report a response rate of over 81% with cell phones when compared to web survey (21%) within college students. Most K-12 schools have ARS technology currently in use. Given that, ARS offers to remove these externalities that often accompany other survey methods and provide a convenient mode of responding to a survey, thus resulting in a higher response rate. Minimal differences are reported (Table 2-2) between mean and SD across items using ARS mode when compared with the paper-and-pencil mode. The ready accessibility and instant polling nature of ARS contribute greatly to the overall convenience of responding. For surveys that are conducted in structured environments such as classrooms, ARS offer reliable response rates that are equivalent to paper-and-pencil surveys. However, this is of little value if the responses are not reliable and valid. For this, one must conduct a formal test of equivalence.

2-4.2 Quantitative equivalence testing

It is challenging to know whether differences found across modes are statistically significant if studies do not use NHST (Epstein et al., 2001). Only a few studies have done so (Weigold et al., 2013).

2-4.2.1 Equivalence testing using paired sample t-test: Using NHST (i.e., paired sample t-test), I report significant results ($p<0.05$; Table 2-3) for most of the items across pre and post surveys. Although this indicates some differences, the differences are due to the power of the t-test with a correspondingly large sample size ($n=1498$). Given NHST, the paired t-test has the null hypothesis that the mean difference is zero; the alternative is that the mean difference is not zero. Thus, the reported differences significance could be misrepresented to state non-equivalence. Thus, it becomes necessary to use a formal test of equivalence.

2-4.2.2 Threshold of equivalence testing using paired sample t-test: Equivalence testing using paired t-test indicates equivalence across modes. Although a significant p-value for the t-test indicates that the two modes produce statistically significant results, it does not give evidence if these differences are large enough to be not considered equivalent for survey research. Thus, it is important to discuss threshold Δ. The threshold Δ represents a difference that is not large enough to have any substantial implications. Threshold results (Table 2-4) signify that the differences of responses between ARS and paper-and-pencil are large enough to be detected under NHST but not large enough to conclude that two modes (ARS and paper-and-pencil) are not equivalent. Specifically, I can detect the Δ threshold at which items stay equivalent (Appendix D, Table 2-1 and 2-2).

2-4.2.3 Equivalence testing using dependent paired-samples equivalence test: The results of mean equivalence tests indicate that results under NHST using paired sample t-tests and a formal equivalence test do not have to agree when comparing for equivalence (Cribbie, Gruman, and Arpin-Cribbie, 2004). The paired t-test and the equivalence test gave different results. The paired t-test tests whether there is a significant difference at the subject level. Under the equivalence test, the null hypothesis is that the absolute value of the effect is greater than delta (not equivalent), and the alternative is that the absolute value of the effect is less than delta (equivalent). Wherein a significant p-value for the equivalence test informs whether or not ARS mode yields equivalent data when compared to the paper-and-pencil mode. Thus, the equivalence test truly assesses if the two modes are equivalent.

The dependent paired-samples equivalence tests on all survey item responses were similar at large effect size or .50 delta level. The paired-samples equivalence test tests whether students are responding equally, or not, using ARS versus the paper-and-pencil mode. At the .30 delta level, or moderate effect size, the responses between modes for all students were equivalent except for item 7 (Table 2-5).

I compared ARS with the most commonly used mode, which is paper-and-pencil, but equivalence with other modes needs to be conducted further. The overall pattern of results supported mean equivalence across ARS and paper-and-pencil mode, although the findings were inconclusive for several comparisons at small effect sizes. The results of multiple equivalence tests (NHST, mean equivalence) indicated that not all comparisons were equivalent. These results indicated that future ARS mode comparisons should use complete and/or appropriate statistical analyses to determine equivalence.

2-4.3 Potential ARS benefits

Given the results described above, I suggest ARS offers multiple advantages in surveying a youth population. ARS can offer increased engagement with the survey. ARS and similar polling systems offer multiple stimuli from their interactive interface furthered by novelty of the instrument itself. To obtain good quality survey responses during a self-administered survey, respondents are required to engage cognitively and to be motivated with the survey completion task (Jenkins and Dillman, 1995, 1997). ARS acts as a motivating tool and offers a unique way for individuals to engage with the content (i.e., the audio-visual appeal).

The use of ARS appears to increase participant cognitive engagement with survey questions, enhancing participation and completion leading to equivalence. Given sufficient time, ARS mode utilizes all four steps of the cognition model (Tourangeau and Rasinski, 1988). It allows respondents to comprehend the questions, undergo retrieval, decide, and report their choice in a timely manner. ARS also is able to engage all respondents simultaneously. ARS is conducted in a classroom setting, and this engages the social norm and validates respondent's engagement with the survey in a way that paper-and-pencil techniques lack. Individuals appreciate knowing that others in their group have completed a similar task (visible via ARS), thus increasing willingness to comply (Cialdini 1984; Groves, Cialdini, and Couper, 1992). Using ARS and its real-time nature provide the strongest evidence to respondents that others are engaged in the same task, which engages the social group as a whole in completion of the survey.

ARS can be utilized to reduce satisficing. The social convention to be polite is powerful. There is a certain agreement with others that is reflected in other less private methods of data collection (telephone, interview, paper) (Brown and Levinson 1987, Leech 1983). It has been shown that higher task difficulty increases satisficing (Krosnick 1991). ARS reduces task difficulty given the group engagement it becomes a collective exercise. The live display allows participants to view completion of a given survey question by the audience. This creates a norm to respond. Furthermore, the automated nature of ARS allows the participants to get engaged which increases completions. Alternatively, it could be that the live display of total responses generates a social norm for responding and, thus, motivates respondents. The face-to-face interaction involved in ARS also seems to motivate youth respondents to answer survey questions.

The anonymous nature of ARS can help in surveys of student populations to provide important data to policymakers and researchers on sensitive topics such as underage drinking of alcohol, drug usage, risky student behavior, and school safety. ARS mode can also be used in polling to provide feedback between survey items. This can create live interventional studies of before and after effect and provide quick audience polling. In classroom settings, multiple researchers can use ARS to conduct identical testing procedures across survey sites, thus, allowing for rapid data acquisition and extraction. Given the group nature of data collection, it allows data collected from large sample sizes simultaneously to be stored digitally.

2-4.4 Potential ARS limitations

ARS possesses several limitations as a data collection tool. The primary limitation of ARS is that its usage is restricted to a formal classroom environment and structured settings. Often such structured settings allow the use of monitor that is needed to project ARS mode, which makes it interactive for participants but it also places a limitation on the use given the need of projection screens/monitors. ARS use can be limited due to the cost and training of the research staff. The research staff must be trained in delivering the same content across multiple classrooms and settings. The lack of proper training between various researchers could increase greatly increase any differences that might exist in classroom testing conditions. Furthermore, ARS requires a combination of projection systems and audio-visual equipment in classroom settings. Any ARS system will need to have transmitters (e.g., Clickers usually range from $40-55), receivers, and software. As with any method, researchers need to decide on an experimental procedure that balances the costs and benefits of utilizing a more expensive mode of data collection such as ARS.

A current limitation that is unique to the ARS method (compared to web, e-mail, or paper-pencil) is that participants can only provide single-key responses using the ARSs. This means that participants cannot type whole words, which disallows open-ended questions. Alternatively, there are newer technological tools, for example- polleverywhere and REEF polling © and open source wiki survey (Salganik and Levy, 2015) that allow open-ended answers to be collected. Use of ARS also disallows retroactive corrections that could be advantageous depending on the type of survey work being conducted. Furthermore, not all respondents can answer quickly and the use of ARS in groups requires allowance of more time for questions when needed.

2-5 Recommendations and conclusion

Numerous constrains have led to a relative lack of accessibility to youth respondents for survey work, pointing to a real need to identify a survey mode able to engage youth. Youth are able to integrate well with interactional technology (Lewis and Fabos, 2005). Technological tools such as ARSs have the potential to process a large number of youth responses simultaneously, making them well suited for data collection. Based on the results of this ARS study, I have demonstrated within a youth sample the general equivalence of ARS and the paper-and-pencil mode on survey-based questionnaires. Furthermore, the study demonstrates that measurement equivalence can be gathered. There is inadequate literature on the use of ARS in conjunction with other survey collection modes to assess equivalence. This research provides an example of how to do so for future studies on ARS that wish to examine equivalence between modes. It is vital that future studies use repeat measures across modes where such equivalence comparisons can be conducted. Future ARS studies should compare all forms of equivalence (quantitative, qualitative, and auxiliary). In this study I did not perform qualitative equivalence study given inadequate items within ARS mode to assess internal consistencies, intercorrelations, and/or factor structures. However, formal equivalence test showed all items to be equivalent.

ARS in this study were engaging for the youth. I suggest that in survey conditions that allow for a structured audience, ARS can become an important method of data collection. However, future studies will need to establish reliability of ARS along with other modes in multiple settings and conditions besides classrooms. Structured audiences similar to classrooms can be found in museums, science centers, youth summer education camps, extension programs, and organized field trips. ARS can be tested widely within these youth audiences. Future studies should assess if reliability and validity are maintained with the use of ARS under such settings.

Appendix A, Table 2-1: Survey Methods and Response Rates from 1978-2014 (%).

Authors	Survey Method Employed							
	Paper/ Mail	Oral/ Face to Face	E-mail	Web	Fax/Disk by Mail	Automated/ Telephone	Cell Phones	ARS[+]
Heberlein and Baumgartner (1978)	60.6*							
Kiesler and Sproull (1986)	75			67				
Sproull (1986)	73	87						
Walsh et al. (1992)			76	66				
Schuldt and Totten (1994)	56.5		19.3					
Mehta and Sivadas (1995 a, b)	45		40	56.5				
Tse (1998)	27		6					
Baruch (1999)				39.6				
Med Lin, Roy and Ham Chai (1999)	47			28				
Donovan, Drasgow and Probst (2000)	65.1			50.1				
Kwak and radler (2000)	42		37					
Meekins, Weaver, Fries (2000)	48		37					
Cobanoglu, Warde and Moreo (2000)	26.2		44.21	17				
Cook et al. (2000)	55.6							
Boyer et al. (2001)	41.4		37.4					
Crawford et al. (2001)			34.5					
Klassen and Jacobs (2001)	23		14		20			
McCabe (2002)	40			63				
Truell, Bartlett and Alexander (2002)	53		51					
Watt et al. (2002)	32.6			33.3				
Sax, Gilmartin and Bryant (2003)	22			19.8				
Bunz(2004)								>95
Dommeyer et al. (2004)	75			43				
Cole, Bedeian and Feild (2006)	52			58				
Parks, Pardi and Bradizza (2006)				60		45.7		

Sheehan (2006) *			39.77					
Langley, Cleary and Kostic (2007)								100
Iran-Nejad and Thoma (2007)	+			+				
Heerwegh and Loosveldt (2008)		90.4		52.5				
McCarter and Caza (2009)								>90
Gravlee et al. (2013)	+	+		+				
Woo, Kim and Couper (2014)				21			81	

Notes: + Response rate reported, but completion is calculated.* Indicates meta-analysis

Appendix B: ARS and paper survey Items utilized in the testing.

Item 1: During the past month, how much class time has been spent talking/discussing renewable energy?

Item 2: How often do you talk with your family about renewable energy at home?

Item 3: How often do you talk with your teachers about renewable energy?

Item 4: How often do you talk with other students about renewable energy?

Item 5: To me using renewable energy is harmful-beneficial

Item 6: To me using renewable energy is expensive-cheap

Item 7:If or When I learn about renewable energy, I feel Sad-happy

Item 8:Since the school pays for electricity, we (students) should not worry about turning lights off in the classroom.

Item 9: In the past year, how much have you learned about renewable energy?

Item 10:I would like to learn about renewable energy.

Item 11: I would be more likely to learn about renewable energy if my friends want me to.

Item 12: I think that renewable energy is very important in solving energy problems that face our country.

Item 13: Overall, learning about renewable energy has increased my interest on the topic.

(Note: Item 1-8, sampling Aug-Sept 2012; items 9-13, sampling May-June

Appendix C, Table 2-1: Wilcoxon signed rank rest for missing values between ARS and Paper-and-Pencil on repeated post-survey items only

Ranks

		N	Mean Rank	Sum of Ranks
Missing Values between ARS and Paper-and-Pencil	Negative Ranks	19[a]	61.00	1159.00
	Positive Ranks	69[b]	39.96	2757.00
	Ties	141 0[c]		
	Total	149 8		

a. Missing Paper < Missing Clicker

b. Missing Paper > Missing Clicker

c. Missing Paper = Missing Clicker

Test Statistics[a]

	MissingPaper- MissingClicker
Z	-3.451[b]
Asymp. Sig. (2-tailed)	.001

a. Wilcoxon Signed Ranks Test b. Based on negative ranks.

Note: Since the missing values for repeat survey items across ARS or paper-and-pencil were not normally distributed across students, the missing values for five survey items (9-13) were subjected to Wilcoxon signed rank test (appendix B, Table 2-1). The differences are significant (Wilcoxon signed rank test, $z = -3.451$, $P < 0.01$, two-tailed) between the average numbers of missing values across modes for these five items.

Appendix C, Table 2-2: Wilcoxon signed rank test for percentage of missing values between ARS and Paper-and-Pencil on all survey items.

Ranks

		N	Mean Rank	Sum of Ranks
Missing values between All ARS and Paper-and-pencil survey	Negative Ranks	76[a]	43.97	3342.00
	Positive Ranks	20[b]	65.70	1314.00
	Ties	140 2[c]		
	Total	149 8		

a. All Clicker < All Paper

b. All Clicker >All Paper

c. All Clicker = All Paper

Test Statistics[a]

	All Clicker – All Paper
Z	-3.795[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test b. Based on positive ranks.

Note: Due to unequal number of questions within both modes I assessed total percent of missing values across mode. Here again, the percent missing values were not normally distributed and were subjected to a Wilcoxon signed rank test (appendix B, Table 2). The percent missing values across ARS and paper-and-pencil mode is found to be significant (Wilcoxon signed rank test, $z = -3.795$, $P < 0.01$, two-tailed).

<u>Appendix D: Quantitative Equivalence</u>

Table 2-1: Paired-Samples Equivalence Procedure between Paper and ARS responses (Aug-Sept, 2012)

Item #	t value	Delta	P, two-tailed	Item #	t value	Delta	P, two-tailed
1	-2.87	.017	.983	5	-.04	.017	.240
	-2.87	.031	.934		-.04	.031	.093
	-2.87	.080	.260		-.04	.080	.000
	-2.87	.110	.025		-.04	.110	.000
	-2.87	.160	.000		-.04	.160	.000
	-2.87	.290	.000		-.04	.290	.000
	-2.87	.470	.000		-.04	.470	.000
	-2.87	.530	.000		-.04	.530	.000
2	-.03	.017	.238	6	8.65	.017	1.000
	-.03	.031	.092		8.65	.031	1.000
	-.03	.080	.000		8.65	.080	1.000
	-.03	.110	.000		8.65	.110	1.000
	-.03	.160	.000		8.65	.160	.942
	-.03	.290	.000		8.65	.290	.000
	-.03	.470	.000		8.65	.470	.000
	-.03	.530	.000		8.65	.530	.000
3	3.31	.017	.999	7	-13.26	.017	1.000
	3.31	.031	.974		-13.26	.031	1.000
	3.31	.080	.420		-13.26	.080	1.000
	3.31	.110	.064		-13.26	.110	1.000
	3.31	.160	.000		-13.26	.160	1.000
	3.31	.290	.000		-13.26	.290	.578
	3.31	.470	.000		-13.26	.470	.000
	3.31	.530	.000		-13.26	.530	.000
4	1.26	.017	.697	8	1.91	.017	.877
	1.26	.031	.461		1.91	.031	.709
	1.26	.080	.012		1.91	.080	.055
	1.26	.110	.000		1.91	.110	.002
	1.26	.160	.000		1.91	.160	.000
	1.26	.290	.000		1.91	.290	.000
	1.26	.470	.000		1.91	.470	.000
	1.26	.530	.000		1.91	.530	.000

Table 2-2: Paired-Samples Equivalence Procedure between Paper and ARS responses (May-June 2013)

Item #	t value	df	Delta	P, two-tailed		Item #	t value	df	Delta	P, two-tailed
9	3.10	1442	.017	.991		12	6.91	1411	.017	1.000
	3.10	1442	.031	.961			6.91	1411	.031	1.000
	3.10	1442	.080	.366			6.91	1411	.080	1.000
	3.10	1442	.110	.050			6.91	1411	.110	.986
	3.10	1442	.160	.000			6.91	1411	.160	.521
	3.10	1442	.290	.000			6.91	1411	.290	.000
	3.10	1442	.470	.000			6.91	1411	.470	.000
	3.10	1442	.530	.000			6.91	1411	.530	.000
10	8.41	1440	.017	1.000		13	3.92	1441	.017	.999
	8.41	1440	.031	1.000			3.92	1441	.031	.995
	8.41	1440	.080	1.000			3.92	1441	.080	.682
	8.41	1440	.110	1.000			3.92	1441	.110	.205
	8.41	1440	.160	.928			3.92	1441	.160	.001
	8.41	1440	.290	.000			3.92	1441	.290	.000
	8.41	1440	.470	.000			3.92	1441	.470	.000
	8.41	1440	.530	.000			3.92	1441	.530	.000
11	-1.39	1441	.017	.746						
	-1.39	1441	.031	.524						
	-1.39	1441	.080	.020						
	-1.39	1441	.110	.000						
	-1.39	1441	.160	.000						
	-1.39	1441	.290	.000						
	-1.39	1441	.470	.000						
	-1.39	1441	.530	.000						

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CHAPTER 3:

UNDERSTANDING LINKAGES BETWEEN TRAINING PROGRAMS AND THE MOTIVATION TO TEACH RENEWABLE ENERGY SUSTAINABILITY, AND ENVIRONMENTAL TOPICS

Abstract

The main focus of environmental and energy education programs has been to motivate teaching behavior by increasing knowledge. Prior studies have focused on the role of training but not under quasi-experimental conditions. This study investigated whether education leads to changes in environmental attitudes and subsequent behavior of teachers. I explore the relationship between teacher training and likelihood of teaching renewable energy and sustainability (i.e. teaching behavior) across Northeast, Mid-Atlantic, and Midwestern schools. I utilized a nonequivalent control design and structured questionnaires from trained and untrained teachers (n=214). A generalized binomial logit model was used to predict teaching behavior on topics related to renewable energy, environment, and sustainability. I reported environmental attitudes are not good predictors of teaching behavior. However, positive attitudes toward the topic of energy and teaching increase the likelihood of teaching behavior. I find effects of age: teachers from the baby boomer and generation ‘x’ had the highest odds of teaching environmental education when compared with millennial generation teachers. Finally, I show that duration of the program (one-week versus three weeks) has no effect on likelihood of teachers teaching the material and results in similar attitudinal shifts. This work suggests that EE programs must examine beyond educational training such that information acquired during

training must be transferred into knowledge and knowledge into action.

Keywords: *'Renewable energy'; 'sustainability'; 'teacher training'; 'environmental education'; 'environmental attitudes'; 'energy attitudes'; 'behavior'*

3-1 Introduction

The Tbilisi Declaration (UNESCO, 1980) on environmental education (EE) emphasizes that individuals should be equipped with knowledge, values, and skills that enable transformation and behavior change. A vast body of work has examined the role of human values, beliefs, norms, and worldviews in driving environmental behavior (Stern 2011; Schultz and Kaiser 2012; Heberlein 2012). EE is based on the theory that greater knowledge will enable the individual to adopt pro-environmental attitudes. The emphasis on environmental education and training is believed to help individuals gain the necessary environmental knowledge, awareness, and attitudes, to lead them to take pro-environmental actions (Hungerford and Volk, 1990; OECD, 2009; 2011). Social-psychological research has provided a systematic perspective on assessing, understanding, and changing environmental behavior (e.g., McCright, Charters, Dentzman and Dietz, 2015), enabling assessments of educational tools. Such assessments provide information on when and how individuals behave more pro-environmentally. Much of EE appears to be rooted in the presumption that people simply need more education to behave pro-environmentally, or the 'information deficit model' (Burgess, Harrison, and Filius, 1998, p. 1447), which assume that given sufficient education or training, individuals will engage in more pro- environmental behavior(s). Many publicly funded programs and non-governmental organizations (NGOs) still base training programs on this model (NAAEE, 2011; NAS, 2007; Owens, 2000).

3-1.1 *Environmental and energy education*

An increased emphasis on providing training on topics such as environment, energy, and sustainability has led national agencies to proclaim a critical need for K-12 schools to prepare the next generation of citizens who are environmentally literate (NAAEE, 2011; NAS, 2007). Such literacy requires that educators are trained effectively to teach environmental topics; similar calls have been issued from Ministers of Education worldwide (UNESCO, 2007), policymakers, and educators from international organizations (NAAEE, 2011).

Science educators formulated the study of energy education in the mid-1970s (Morrisey and Barrow, 1984); such programs are a natural fit within environmental education (Campbell, 1977). Environmental concerns have prompted the need for effective education about renewable energy (Thomas, Jennings, and Lloyd, 2008), and this education is integrated typically within Science, Technology, Engineering, and Math (STEM) teacher training programs which are meant to increase energy-related knowledge (Curry, Ansolabehere, and Herzon, 2007; NEETF, 2002).

3-1.2 Understanding environmentally significant behaviors

Environmental attitudes are a commonly engaged construct in environmental psychology and environmental education research (Kaiser, Wolfing and Fuhler, 1999; Milfont, 2007). As such, measures that deal with environmental attitudes are numerous (Dunlap and Jones, 2002), often overlap (Milfont and Duckitt, 2010). Despite the large number of EA measures, only three have been widely used and had their validity and reliability assessed (Dunlap and Jones, 2003). These measures (i.e. the Ecology Scale, Maloney and Ward, 1973, the Environmental Concern Scale, Weigel and Weigle, 1978, and the New Environmental Paradigm (NEP) Scale, Dunlap and Liere, 1978) all examine multiple expressions such as beliefs, attitudes, intentions, and behaviors. They further examine differing topics. This has led some to state that these measures are often unsystematic (Heberlein and Black, 1981; Stern, 1992). Despite these issues, few studies have reported meta-analyses on the issue (Stamps, 2002). Although dated, Hines, Hungerford, and Tomera (1986) have conducted the most extensive meta-analysis on the purported relationship between environmental attitudes and environmental behavior. They found weak/moderate correlations between positive environmental attitudes and pro-environmental behavior. Studies since then have shown little consensus of the extent to which pro-environmental attitudes dictate environmentally significant behavior (Klöckner, 2013).

Bamberg and Möser's (2007) meta-analysis (57 studies) indicated that pro-environmental behavior is governed by attitudes, self-interest and pro-social motives. Most results pertaining to the effects of attitudes on pro-environmental behavior are inconclusive and contradictory, with little consensus on any of these conclusions among practitioners in the field (Heimlich and Ardoin, 2008). Kollmuss and Agyeman (2002: 243-244) state, 'The relationship between knowledge and attitudes, attitudes and intentions, and intentions and actual responsible behavior, are weak at best'. However, Kaiser et al. (1999) have suggested that environmental attitudes are powerful predictors of ecological behavior. But environmental attitudes, even when present, must be accompanied by an inherent ability to perform a given behavior, or perceived behavioral control (PBC), which is the efficacy or the ability of a person to perform a given behavior. According to Larson and others (2015) participation in pro-environmental behaviors is impacted by the underlying social and contextual factors which results in variables rates of participation across wide range of pro-environmental behaviors.

3-1.3 Environmental education and behavior

DeWaters and Powers, (2011) have underscored the need for educational training programs that improve literacy by impacting attitudes, values, and environmental behaviors. Environmental education is focused on fostering environmental behavior. Teaching about environment and using sustainable energy choices is a unique type of *environmentally significant behavior (ESB).* Understanding the processes that underpin ESB in the form of increased energy awareness and environmental concern is crucial for identifying attitudinal determinants.

A lack of systematic evidence exists on whether environmental education programs have a long-term sustained impact on attitudes, beliefs, norms, and behavior. Training programs measure gains made through directed training across wide-ranging cognitive, behavioral, attitudinal, and affective outcomes (Farmer, Knapp, and Benton, 2007; Jordan, Hungerford, and Tomera, 1986; Nadelson and Jordan, 2012; Smith-Sebasto and Semrau, 2004). Often these programs have found short-term gains in cognitive and affective outcomes (Dettman- Easler and Pease, 1996; Jordan, Hungerford, and Tomera, 1986; Knapp and Benton, 2006).

Control beliefs in particular are associated with a variety of cognitive, affective, and behavioral outcomes (Bandura, 1986; De Brabander, Boone, and Gerits, 1992; Ganster and Fusilier, 1989). It has been shown that control beliefs and individual sense of responsibility are equally important in an individual’s willingness or intent to undertake a pro-environmental behavior (Kollmuss & Agyeman 2002). It is consequential in structured learning environments such as K-12 schools since it deals with the presence or absence of factors that facilitate or inhibit adoption of the ESB by teachers.

3-1.4 The effect of educational training programs

There is a lack of empirically analyzed research on whether educational training can trigger a change in environmental norms, values, and the resultant behavior. Information in itself does not cause behavioral changes (Schultz, 2002, Hungerford and Volk 1990, Stern 2000), but not having relevant information is a deterrent in adopting new behavior (Schultz 2002, Kaplan 2000, DeYoung 2000). Amongst other factors, prior educational training programs have been evaluated given pre-posttest measures, duration of the training, and effects of group size during the training. These factors are discussed next.

3-1.4.1 Post-evaluation of environmental education programs: Many of the training programs measure a pre- and post-valuation over compressed time frames (Engels and Jacobson, 2007) with the post survey data often limited to the day of training completion. These short-term studies have been defined as those that focus on post surveys within 4-5 weeks after the program (Randler, Ilg, and Kern, 2005), and three months (Dettman- Easler and Pease, 1999; Flowers, 2010) following the program.

Previous research has shown that post-program interventions (repeated or sustained) over longer periods of time help sustain positive impacts of the directed educational programs (Covitt, Gomez-Schmidt, and Zint, 2005; Ernst, 2005; Powers, 2004). However, few studies have addressed whether these short-term gains in change of attitudes are sustained when long-term follow-up measures are utilized (Stern, Powell and Ardoin, 2008). A meta-analysis of environmental education evaluations (Schneider and Cheslock, 2003) revealed only five peer-reviewed evaluations between 1991 and 2000 that reported student-based outcomes three months or more after completion of programs. More recent work shows that there is stabilization or in some cases a decline in effectiveness of the program after five years in trained environmental educators (Stevenson, Peterson, Bondell, Mertig, and Moore, 2013); any long-term sustained impacts of programs thus fail to occur.

3-1.4.2 Effect of duration of training program: Stern et al. (2008) discussed the lack of conclusive findings on the effect of duration of environmental education programs, stating that most teachers and researchers assume longer programs produce greater effects. However, other studies have demonstrated similar effects between a one-day field trip and when measured after a 30-day period on knowledge retention within K3 and K5 grades over (Falk and Balling, 1982). Powers (2004) indicated location and economic status of participants are far more influential than the duration of the training program.

3-1.4.3 Effect of group size on training programs: Researchers have assumed that smaller group size impacts education outcomes positively (Riggins, 1986). Some have found no significant effects of group sizes (Orams, 1999), but others have suggested that an ideal group as "ten-group" with an optimal group size of 7-15 (Walsh & Golins, 1976). Within formal educational settings, groups of 15 are deemed beneficial (Glass, Cahen, Smith and Filby, 1982), sustaining diversity and allowing group interaction (Walsh and Golins, 1976). However, a larger study refuted these claims and showed that differences in group size ranging from 5-26 had no long-term effects on 3,000 Outward Bound participants (Neill, 2004).

3-1.5 Statement of purpose and research questions

Prior to this study, trained teachers have not been compared with untrained teachers to assess empirically the exact effects of educational training. I seek to determine if training leads to pro-environmental and energy attitudes, thus, resulting in a “foot in the door effect”- the process by which a slight behavioral change in teachers can set in motion psychological changes (Swim et al., 2011). I propose that teaching about renewable energy, environment, and sustainability is a unique form of indirect ESB.

Stern (2000) characterized ESB as indirect behaviors that can significantly affect the environment through other behaviors, such as influencing the actions of individuals in organizations to which they belong. K-12 school is one such organization where teachers operate. Teachers who teach topics that pertain to environmental, sustainability, and renewable energy are indirectly engaging creating opportunities where ESB could occur. One such instance would be when teachers already engaged in teaching such topics act mediators for their peer teachers, who otherwise may not have taught to teach similar topics. The teachers also indirectly motivate students to undertake actions that may help the environment. I assume that the teachers that are more likely to be influenced by training will be more likely to teach and design lesson plans, labs, and activities on environmental topics. Renewable energy as a broader topic is not a critical focus and neither is it typically a part of required curriculum Thus, teachers teaching renewable energy, environment, and sustainability are demonstrating a level of engagement that is not required of them. Henceforth, I will discuss ESB as it pertains to teachers’ teaching of these topics with their students as the ***teaching behavior***.

The following research questions were assessed in this study:

I. Are there differences in teachers' teaching behavior relating to:

    a. The length, and group size of the training program

    b. Age, gender, school, income district, and state (socio-demographic variables)

II. Are trained teachers more likely to display pro-environmental attitudes than untrained teachers?

    a. Are there attitudinal differences toward renewable energy between trained and untrained teachers?

III. What is the relationship between teacher's attitudes and likelihood of teaching behavior or ESB?

3-2 Theoretical Framework

A conceptual framework for analyzing multiple causes of teacher behavior is the Reasoned Action Approach (Fishbein and Ajzen, 2010, Figure 3-1). The RAA model utilizes beliefs about particular outcomes and referents' approval regarding the behavior as antecedents, and intentions and behaviors as consequences of attitude and subjective norm constructs. RAA stipulates that a small number of variables can be identified that together can explain a substantial proportion of the variance in any behavior in any population (Fishbein, 2008; Fishbein and Ajzen, 1975, 2010).

The RAA model states that intention is a function of three types of perceptions: attitude, perceived norm, and self-efficacy. Attitude, moral norm, and PBC are often predictive of behavior (Armitage and Conner, 2001; Bamberg and Möser, 2007). Attitude is a teacher's evaluation of how favorable or unfavorable their performing a particular behavior would be. Perceived norm is the social pressure that a teacher expects to receive for exhibiting the behavior, and it has two aspects, an injunctive and a descriptive norm. An injunctive norm is the extent to which other teachers, school personnel, parents, and students are expected to be

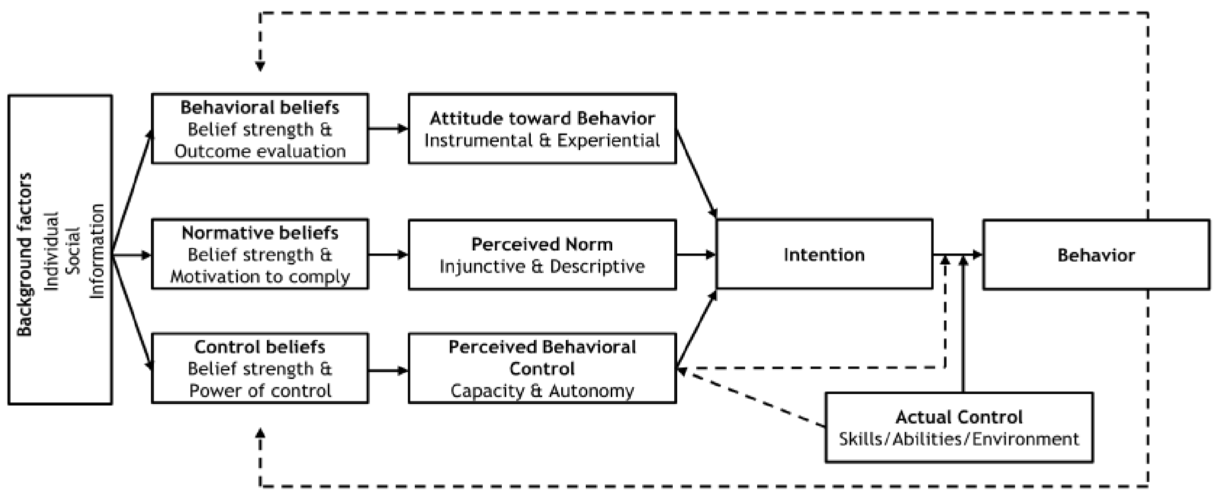

Figure 3-1. A Reasoned Action Approach (RAA) model used to investigate the relationship of training and its effect on teachers' likelihood to teach the topics related to renewable energy and sustainability.

supportive of the teacher performing the behavior, and a descriptive norm is the extent to which teachers perform the behavior themselves. Normative belief is the level of expected support from the network of teachers, such as the specific members of important social networks (injunctive norm beliefs), and beliefs about the extent to which these specific individuals teach the topics in question as well (descriptive norm beliefs).

Behavioral belief is a general sense of favorability or (dis)favorability regarding the performance of a behavior and the likelihood that performing the behavior will have certain outcomes (outcome beliefs). The three types of beliefs, behavioral, normative, and control are each associated with the behavior such as, “an outcome, a normative expectation, or resource needed to perform the behavior” (Ajzen, 1991, p.198). As such, RAA allows us to determine the beliefs underlying teachers’ intent to teach energy and environment topics in their classroom. Finally, self-efficacy is a function of perceived capability in specific challenging or facilitating circumstances (efficacy or control beliefs).

Ability to perform a behavior (i.e. PBC) reflects the extent to which a teacher feels confident of performing the teaching behavior effectively. PBC is not the same as competence, which according to the model refers to actual skills, whereas self-efficacy refers to perceived capability. Self-efficacy is the teacher’s perceived capability to perform a behavior successfully. Locus of Control (LOC) represents an individual’s perception of whether they have the ability to bring about change through their own behavior (Newhouse, 1991). It has been shown that LOC and an individual sense of responsibility are equally important in an individual’s environmental behavior (Kollmuss and Agyeman 2002).

LOC is one of the four components, along with self-efficacy, self-esteem, and emotional stability, of the higher-order construct that is PBC (Judge, Locke, Durham and Kluger, 1998). LOC is a predictor of the tendency for people to exert active control over their environment. In doing so, LOC represents the extent to which an individual exhibits control in performing a behavior. LOC as a construct has a strong cognitive focus and is related to attitudinal outcomes (Lefcourt, 1992; Ng, Sorensen, and Eby, 2006). LOC has a strong relationship with the measure of one’s self-worth (Judge and Bono, 2001). Rotter (1966) identified LOC to be of two types: internal and external LOC. Externals are those that exhibit lack of control and influenced by external motivators, while internals believe they can control their environment and consequences. Internal LOC individuals are more sensitive to perception of self-worth than externals (Phares, 1976) and externals typically regard their behavior as unlikely in bringing about change (Ng, et al. 2006). Teachers' control belief determines their Internal and external LOC and social experiences play a large role in control beliefs (Langer, 1983; Lefcourt, 1976). And thus, control belief is associated with a variety of cognitive, affective, and behavioral outcomes (Bandura, 1986; De Brabander, Boone, and Gerits, 1992; Ganster and Fusilier, 1989).

RAA has been used to predict rational behaviors that are predicated on intentions. Rational behaviors are deliberative: the individual will perform them if they perceive that doing so serves their best interest The behavioral intent is based on specific beliefs that teachers may hold about it (Fishbein, Triandis, Kanfer, Becker, and Middlestadt, 2001). Given the focus of this research on teaching behavior, "reasoned" has to do with the general rule that if teachers believe that teaching renewable energy, environmental topics, and sustainability in classrooms is a positive thing, then they are motivated to perform that particular behavior; conversely they are less likely to engage in the behavior if they believe engaging in the behavior would not be in their best interest.

3-3 Methods

3-3.1 Research context

This study was within a national training program, which is a consortium of nine institutions of higher learning in the Northeastern US that provides professional development workshops to (STEM)+ Agriculture teachers, grades 6 through undergraduate college level.

Teachers from seven different states participated in the in-service program. (Note: specific details of the program are described previously in the introduction chapter 1, of this dissertation)

3-3.2 Experimental design

A quasi-experimental study using a nonequivalent control design group model was conducted. The control group consisted of similar groups (i.e. similar grade levels) of teachers as that of the trained teachers (i.e. experimental group) at the training programs. These were selected within the same school district through a structured interview process. Including a control group allowed assessing and testing if the intervention of training has the desired effect, i.e. trained teachers were compared to control teachers from same school district and similar grade levels. This design is conducive for conducting research on intact groups such as K-12 school classes. It mimics experimental conditions for testing hypotheses, because of the strict criteria and systematic selection of control classes and control educator.

3-3.3 Study participants and data collection

The study participants had various educational backgrounds and were associated with diverse school districts. The participants consisted of pre-service teaching, extension educators, college teachers, and K-12 educators that came from diverse backgrounds. Participants (i.e. trained teachers and untrained or control group of teachers) were drawn from public, private, and charter school districts that represented various income districts as indicated by their participation in the federal Free and Reduced Meal (FARM) program (see Table 3-1 for detailed descriptions). The data collection occurred during 2012-13 in four states: DE, MD, NY, and OH.

The survey tool was administered to teachers who attended a workshop. Surveys prior to training and post-training were implemented at all sites and training consisted of either a 3-week or 1-week long training. The same participants were surveyed in a post-survey after nine months to assess any long-lasting post-training effects, and compared with a control group of teachers that were not trained, which resulted in n=214 (see, Table 3-1).

Table 3-1. Participants' background and characteristics of teachers within the study (n=214)

Participants Background		Frequency (%)
Gender	Men	41.1
	Women	58.9
Race	White	72
	Black or African-American	15
	Asian	5.6
	Hispanic	4.7
	Mixed Race	2.8
Age Group	Baby-boomers (1946-1964)	43.9
	Generation X (1965-1980)	32.2
	Millennial (1981-2000)	23.8
State	New York	51.9
	Delaware	16.0
	Maryland	15.4
	Ohio	11.8
	New Hampshire	1.9
	Pennsylvania	1.9
	New Jersey	0.9
Length of Training	Untrained	16.8
	1-Week	71.0
	3-Week	12.1
School District	Public	73.4
	Private	16.8
	Charter	9.8
Income Districts (FARM)	Low Income	11.7
	Middle Income	66.8
	High Income	21.5

3-3.4 Survey tool

The Reasoned Action Approach (RAA) (Fishbein and Ajzen, 2010) has never been used to evaluate teachers' behavior. The study survey was created in part through utilizing existing measures about renewable energy assessment (Minton and Rose, 1997), energy attitudes (Stedman and McComas, 2010), the International Bioenergy Perceptions and Attitudes Measurement Scale (IBPAMS) for investigating students' perceptions and attitudes toward renewable energy (Halder, Pietarinen, Havu-Nuutinen, and Pelkonen. 2010), and environmental concerns (Dunlap, Van Liere, Mertig, and Jones, 2000). The educator survey questions were developed in consultation with previous preliminary surveys on attitudes of educators toward renewable energy. The resultant survey was field-tested with prior program participants and revised using comments from project staff, researchers in the field, past educators, and research team. The final energy evaluation survey for assessing educators' attitude towards renewable energy was developed and was approved by XXX University IRB (Protocol ID# 1105002254). Participating teachers at the workshops and the control teachers (untrained) signed a written consent form.

3-3.5 Survey measures

The survey items were largely developed based on RAA. Seven questions (gender, age, school district, qualification, grade competency, topics taught, and level of knowledge) were added to assess basic participant characteristics. The items for constructs were developed from focus groups/elicitation interviews with educators. The survey questionnaire consisted of 40 items, comprised of the following key elements: past behavior on energy education; behavioral, normative, and control beliefs on renewable energy teaching and adoption; educators' personal preference for future energy sources; affective items; attitudes towards renewable energy; self-efficacy (PBC); pro-environmental and ecological attitudes.

I have utilized multi-item scales for each of the seven constructs within RAA model. These included behavioral belief, where teachers rated the likelihood of adopting teaching given 7-point scale ranging from very likely to very unlikely; normative belief was measured using injunctive normative belief, i.e., teachers were asked to indicate if students, principals, other teachers, professional development expected them to teach; all items were rated on a 5-point scale. I measured attitudes related to renewable energy, teaching, environment, and anthropocentric using a 5-point likert scale. The scale reliability (αs) for all constructs ranged between 0.60 and 0.91, which indicated acceptable reliability levels. The frequency of behavior was measured using 14 items presented as a dichotomous choice of yes/no and a scale reliability (α= 0.91) and past behavior was assessed with respect to teaching and discussing renewable energy with peer teachers, students, and family based on frequency (α=0.75). The scale reliability of the rest of items was: attitudes towards renewable energy (0.74); attitudes towards environment (0.60), self-efficacy (PBC) (0.62), norms (0.63), behavioral belief (0.78), normative belief (0.82), and control beliefs (0.74).

3.5.1 Dependent variable

The dependent variable (teaching behavior) was measured as the frequency of teaching topics that pertained to renewable energy, environment, and sustainability, this resulted in 14 discrete measures (one for each potential behavior). These measures corresponded to the topics that teachers encountered during the training workshops. The final score for teachers' behavior was created in three steps.

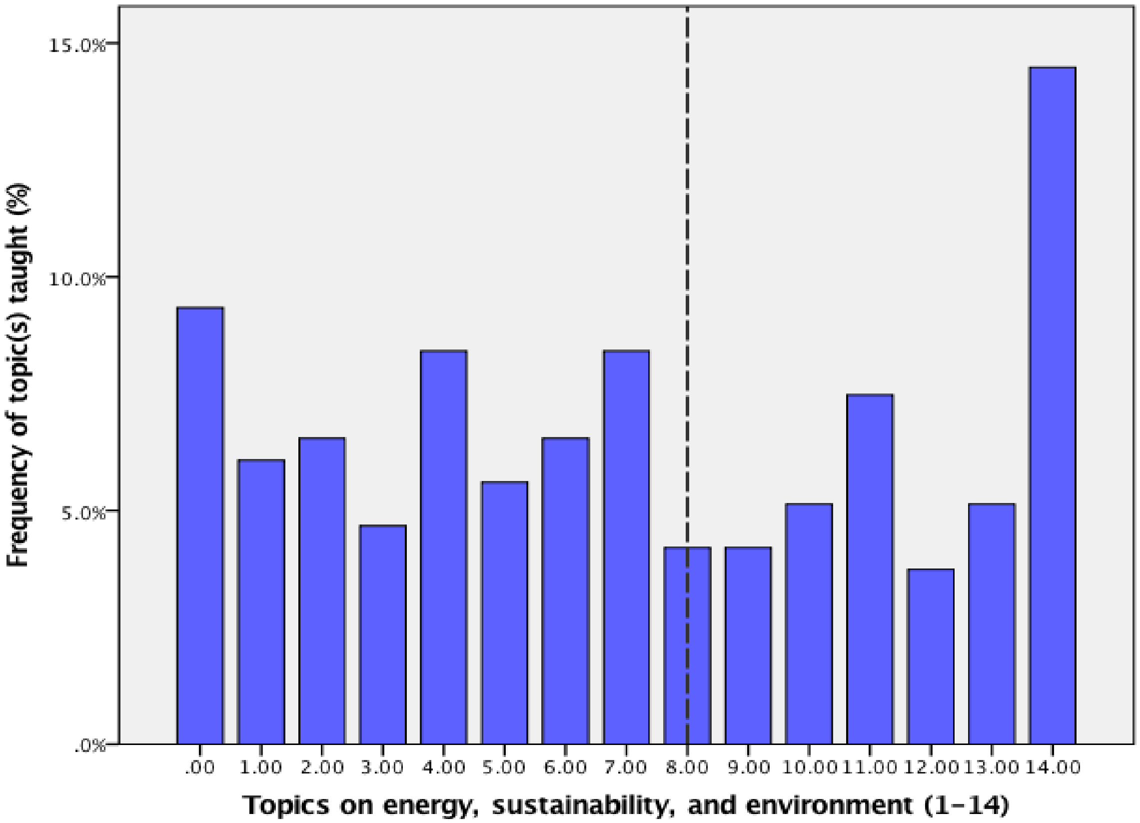

Figure 3-2: Frequency of reported teaching topics 1 through 14 on energy, environment, and sustainability for trained and untrained teachers (n=214).

First, variables were selected to be included in the scale based on the following criteria: The variable represented a topic teachers were trained on specifically during the workshop; they were also equipped with teaching aids which consisted of lesson plans, lab activities, and corresponding visual aids (i.e., Powerpoint slides). This was done such that should a teacher could elect to teach a topic that was not dependent on school-specific initiatives or dictated by school board policy such as Common Core State Standard (CCSS) or New York Regents Exams. All of the teaching materials were accessible to all trained teachers of the programs. Thus, the use of teaching aids and the relevant materials were held constant and the only variable was the teachers' ability or motivation to teach. Responses to each topic were categorized by '0' or '1', where '0' represented not having taught or discussed over a 9-month period after training and '1' represented having taught or discussed the topic. Finally, scores were summed across the 14 topics, which yielded scores that ranged from 0 (i.e. did not teach any topics) to 14 (i.e. taught every topic) for each teacher (Fig. 3-2, previous page).

For purposes of this analysis, I grouped these behavioral actions into a low or a high-action group (i.e., if a teacher had a final score of 8 or less, he/she was deemed to be low action teacher, if greater then 8, he/she was deemed to be a high action teacher). I did this since the median/mean (see fig 3-2, dashed line) of the all teachers (trained or untrained) was between 7 and 8 topics.

3-3.6 Model specifications

A generalized linear model (binomial, logit) was applied to determine the underlying factors that influence the odds of being a high or low action teacher. The external variables external to the RAA model included age group, gender, group size, school district FARM participation (income), state, pre- versus post-survey, training versus no training, and the length of the training. The key independent variables included: past behavior on energy education; behavioral belief, control belief, normative beliefs on renewable energy and teaching renewable energy; attitudes towards renewable energy and environment; subjective norms; perceived behavioral control (i.e. both internal and external), and internal locus of control.

A logit model was employed in this study, because of its ability to represent the complex aspects of the decisions made by individuals (see McFadden, 1981). Logistic results provide readily interpretable odds of moving from one classification to the next (in this case, “low action” to “high action”). It is particularly helpful in this study since employing logit regression permits greater interpretation through the use of odds ratios, and to my knowledge has not been applied to understanding determinants of teacher behavior within the K-12 settings. Studies have shown how dichotomization can yield a more meaningful measure of the underlying relationship (Farrington and Loeber, 2000). Most importantly, unlike in an OLS, in a maximum likelihood estimation (MLE), the values of the estimated parameters are adjusted iteratively in a logistic until the maximum likelihood value for the estimated parameters is obtained (Hoetker, 2007). That is, maximum likelihood approaches try to find estimates of parameters that make the data actually observed "most likely". The general form of model divides teaching behavior into a dichotomous latent variable (high and low action). The results of this study were interpreted using the odds ratio, which is the exponentiated coefficient of the explanatory variables. The odds ratio was calculated by contrasting each category with the reference category. I kept the lowest category in all cases as the default referent choice. The use of the odds ratio helps us to understand under what conditions there would be a greater likelihood of teachers teaching renewable energy and sustainability.

An independent sample t-test was conducted to assess the differences between pre-training and post-training of teachers. Thereafter, variables that best predict the odds ratio were selected through a step-by-step iterative process by looking at social, demographic, and mediators of behavior as theorized with RAA and an optimized best-fit model was obtained. All statistical analyses were conducted using SPSS (v. 24.0 and v. 23.0).

3-4 Results

3-4.1 Descriptive statistics and analysis

The correlation matrix presented in Table 3-2 indicates that the independent variables in the RAA were all associated significantly with self-reported ESB.

Table 3-2. Means, standard deviations and correlations matrix between independent variables used for predicting teaching behavior

Variable	M	SD	1	2	3	4	5	6	7	8	9
1.Behavioral beliefs[a]	5.74	0.26	1	.306**	.096	-.020	.197**	.229**	.124	-.029	.124
2.Control beliefs[a]	4.25	0.31	.306**	1	.089	.045	.261**	.180**	.137*	.016	.093
3.Normative beliefs[a]	4.59	0.57	.096	.089	1	.202**	.257**	.243**	.380**	.212**	.226**
4.Attitudes (environment)[b]	3.43	0.85	-.020	.045	.202**	1	.034	.170*	.334**	.130	.034
5.Attitudes (energy)[b]	3.85	0.52	.197**	.261**	.257**	.034	1	.223**	.305**	.320**	.393**
6.Norms[b]	5.51	0.35	.229**	.180**	.243**	.170*	.223**	1	.246**	.037	.088
7.PBC[b]	4.16	1.16	.124	.137*	.380**	.334**	.305**	.246**	1	.265**	.202**
8.Behavior[d]	0.51	0.13	-.029	.016	.212**	.130	.320**	.037	.265**	1	.197**
9.Past behavior[c]	2.77	0.07	.124	.093	.226**	.034	.393**	.088	.202**	.197**	1

*=p< .05 level, ** = p<.01 level   Scale range for [a]= 1-7; [b]= 1-5; [c] = 1-4; [d] 0 or 1

Energy attitudes are significantly, and positively, correlated with all of the other predicting variables. Participants reported moderate behavioral beliefs (*M=5.74, SD=. 26*), strong control beliefs (*M=4.25, SD=. 31*) and normative beliefs (*M=4.59, SD=. 57),* moderately positive environmental attitude (*M=3.43, SD=. 85*), moderately positive energy attitudes (*M=3.85, SD=. 52*), moderate norms (*M=5.51, SD=* .35), weak past behavior (*M=2.77, SD=.07*) and moderate level of behavior (*M=0.51, SD=. 13*).

The characteristics of the sample with regard to their social-economic/demographic backgrounds, and the composition of the training program are represented in Table 3-3(next page). A minority (31%) of teachers reported teaching more than eight topics out of 14 for which they were trained at their respective schools. Most teachers attended a 1-week workshop (71%) compared to a 3-week training program (12%) and the remainder were the control group of teachers who attended no training workshops (16.8%). About half of the school districts represented were from NY (52%), and the least were from NJ (0.9%), NH (1.9%), and PA (1.9%). The school districts represented from OH, MD, and DE represented 11.8%, 15.6%, and 16% of the total population of districts, respectively. Most of the districts (88%) subscribed to the federal Free and Reduced Meal (FARM) program, which suggested that they were medium to low-income districts. Lastly, teachers represented the three large age-cohort groups- baby boomers (born between 1946-1964; 24.1%), generation X (1965-1980; 32.5%), and millennial (1981-2000; 43.4%).

Table 3-3. Study participant background and characteristic that were part of the full study.

			N	Percent
Dependent Variable	Frequency of Behavior	Low Action	148	69.2
		High Action	66	30.8
		Total	214	100.0
Categorical Factors	Training/Treatment Group	Control (No Training)	37	17.3
		Pre-Training	70	32.7
		Post-Training (1-3 week)	70	32.7
		Post Training (> 9 months)	37	17.3
		Total	214	100.0
	Age Group	3.00 (Millennials, 1981-2000)	51	23.8
		2.00 (Gen 'X', 1965-1980)	69	32.2
		1.00 (Boomers, 1946-1964)	94	43.9
		Total	214	100.0
	Length of Training	3 weeks	26	12.1
		1 week	152	71.0
		No Training	36	16.8
		Total	214	100.0
	Gender	Women	126	58.9
		Men	88	41.1
		Total	214	100.0
	Group Size	Large (>10)	81	37.9
		Medium (6-10)	116	54.2
		Small (<6)	17	7.9
		Total	214	100.0
	FARM	High	46	21.5
		Med	143	66.8
		Low	25	11.7
		Total	212	100.0
	State	NJ	2	0.9
		NH	4	1.9
		PA	4	1.9
		OH	25	11.8
		MD	33	15.6
		DE	34	16.0
		NY	110	51.9
		Total	212	100.0

Table 3-4. Teaching of renewable energy and related environmental topics by gender (n=214)

Topic	*M (women)*	*M (men)*	*M (total)*
1. Climate change	0.66	0.76	0.70
2. Renewable energy systems	0.63	0.74	0.67
3. Energy savings	0.67	0.65	0.66
4. Land use change	0.42	0.45	0.43
5. Carbon emissions	0.47**	0.72	0.57
6. Biomass crops	0.31*	0.49	0.38
7. Bioenergy	0.33**	0.61	0.44
8. Bioproducts	0.28**	0.45	0.35
9. Natural gas	0.38	0.45	0.41
10. Wind energy	0.53**	0.73	0.61
11. Solar energy	0.54*	0.73	0.64
12. Tidal energy	0.27	0.36	0.31
13. Hydroelectric	0.40	0.51	0.44
14. Nuclear energy	0.44*	0.57	0.49

*Note: all items were yes/no and significant differences reported with chi-square test across gender; *=p <.05 level, **=p<0.1 level*

Gender differences were associated with teaching seven of the 14 topics. A majority (59%) of teachers who attended these workshops were women. However, I found that women were significantly (Table 3-4; p<0.01) less likely to teach topics that related to carbon emissions, bioenergy, bioproducts, wind energy. biomass crops, solar energy, and nuclear energy topics

3-4.2 Effect of training, length and group size

Training did not result in significant differences in teaching behavior (Table 3-5, next page), I found no significant differences between the odds ratio associated with or without training.

Table 3-5. Modeled odds ratios of teaching behavior in K-12 educators (n=214) given social-demographic, attitudinal and belief predictors associated with teaching environment, sustainability, and renewable energy topics.

Predicting Variables	*B*	*df*	*Sig.*	*Odds Ratio*
(Intercept)	-15.63	1.00	0.00	0.00
Control (no-training)	0.61	1.00	0.39	1.84
Pre-training	0.44	1.00	0.48	1.55
Post-training (1-week after)	0.03	1.00	0.95	1.04
Post-training (9months after)	0a	.	.	1.00
Group Size= <6* **	**-2.62**	**1.00**	**0.00**	**0.07**
Group Size= 6-10	-0.35	1.00	0.52	0.71
Group Size= >10	0a	.	.	1.00
Length of Training=1 week	-0.47	1.00	0.44	0.62
Length of Training=3 weeks	0a	.	.	1.00
FARM=Low	-0.38	1.00	0.62	0.68
FARM=Med	-0.19	1.00	0.69	0.83
FARM=High	0a	.	.	1.00
Men **	**0.96**	**1.00**	**0.02**	**2.62**
Women	0a	.	.	1.00
Baby boomers* **	**2.32**	**1.00**	**0.00**	**10.19**
Generation ‘x’* **	**2.09**	**1.00**	**0.00**	**8.10**
Millennial	0a	.	.	1.00
Past behavior = None* **	**-3.60**	**1.00**	**0.00**	**0.30**
Past behavior = Infrequent*	**-0.77**	**1.00**	**0.09**	**0.46**
Past behavior = Often	0a	.	.	1.00
Normative beliefs on energy	-0.04	1.00	0.39	0.96
Normative beliefs on education* **	**0.17**	**1.00**	**0.00**	**1.18**
Norms	-0.03	1.00	0.39	0.97
Behavioral Beliefs	-0.05	1.00	0.16	0.95
Control Beliefs	-0.31	1.00	0.09	0.73
PBC*	**0.06**	**1.00**	**0.09**	**1.07**
Internal LOC*	**0.39**	**1.00**	**0.06**	**1.47**
Energy attitudes* **	**0.25**	**1.00**	**0.00**	**1.28**
Environmental attitudes	0.02	1.00	0.62	1.02

Dependent Variable: High or low teaching
a Set to zero because this parameter is redundant.

p= < 0.10 level **=p < .05 level, ***= p < .01 level

I found no significant differences in the odds ratio between pre-training, post training, and the nine months after training Furthermore, the control group (untrained) teachers have similar odds of teaching behavior when compared to trained teachers at the nine-month period indicating lack of effect. Smaller group size (<6 participants) reduced the odds of teachers' teaching by 0.07 times when compared to larger groups of 6-10 and even further reduction of odds in teaching when compared with group size of larger than 10. Men were 2.62 times more likely to be in the high action group when compared to women teachers (Table 3-5, previous page). Nor was teaching behavior influenced by the length of training (i.e. 1-week program was no different than a 3-week training program on increasing teachers' odds of teaching).

I also found that the presence of other teachers' support in teaching and prepared visual aids in the classroom, were found to increase teaching behavior across all teachers. I found that the support of peer teachers was significant across age groups, gender, and training. However, I found larger differences across gender than across training; specifically, gender differences were found across all items except 3, 5, and 7 (Table 3-6, next page).

Table 3-6. Mediators influencing K-12 educators' teaching behavior to teach renewable energy, sustainability, and environmental topic in their classrooms (n=214)

Mediators	*Pre-training*		*Post-training*	
	Mean	*SD*	*Mean*	*SD*
1. Principal support [a]	3.94	1.2	3.97	1.16
2. Support of other teachers [a b c]	3.90	0.96	3.7	1.13
3. Additional educational programs	4.51	0.73	4.55	0.61
4. Additional professional development and training	4.6	0.58	4.68	0.57
5. Structured lessons on topic	3.99	0.9	3.92	1.01
6. Prepared educational materials [a b]	4.65	0.53	4.59	0.62
7. Exchange program with other schools	3.81	1.09	4.1	0.94
8. In-Service Training [a]	4.16	0.9	4.32	0.79
9. Visual Aids [a b c]	4.34	0.84	4.5	0.81
10. Students interest levels on topics [a]	4.33	0.9	4.48	0.78

Note: Letters denote significant differences at p = <0.1 level under chi-square test across *gender* [(a)]*; age group* [(b)]*, and Training* [(c)]*; For gender all items except visual aid and in-service significant at p=<.05 level*

Overall, I found no differences due to training on specific parameters such as the likelihood to teach specific motivators, but I found significant differences across teachers' gender. Women (trained or untrained) were more likely to engage in teaching when topics were formulated as part of a school-wide green initiative, if the principal/superintendent required it, or if there was already a prepared curriculum on the topic (Table 3-7, following page).

Table 3-7. Likelihood of teaching behavior across gender given the presence of specific external motivators for educators (n=214)

More likely to teach if….	*Pre-training*		*Post-training*	
	Mean	*SD*	*Mean*	*SD*
1. Educates students on environment and climate change	5.77	1.35	6.07	1.15
2. Part of local/state green initiative [a]	5.58*	1.52	5.73*	1.48
3. Student enjoy learning	5.98	1.42	6.18	1.34
4. Teaches scientific principles behind climate change	5.83	1.39	6.11	1.23
5. Principal or superintendent requires it [a]	5.51**	1.54	5.45**	1.63
6. Prepared curriculum/lessons on it [a]	5.45**	1.63	5.27**	1.68
7. Students seek information	5.67	1.12	5.8	1.15

Note: Letters '[a]' denotes significant differences reported under chi-square test across gender; *=p <.05 level, **=p<0.1 level

3-4.3 Effects of age, gender and knowledge on behavior

A similar percentage of men and women engaged in higher levels of teaching (i.e. taught 8 or more topics in their classrooms) (Figure 3-2, next page). I found similar percentage of men and women that belonged to the high action group (i.e. 16.9% of men and 14% of women respectively (Fig. 3-3). However, I found substantial differences existed within the category of low action group as described by the teachers' gender (i.e. 44.8% of women teachers) did not engage teaching more than eight topics out of 14 after their training.

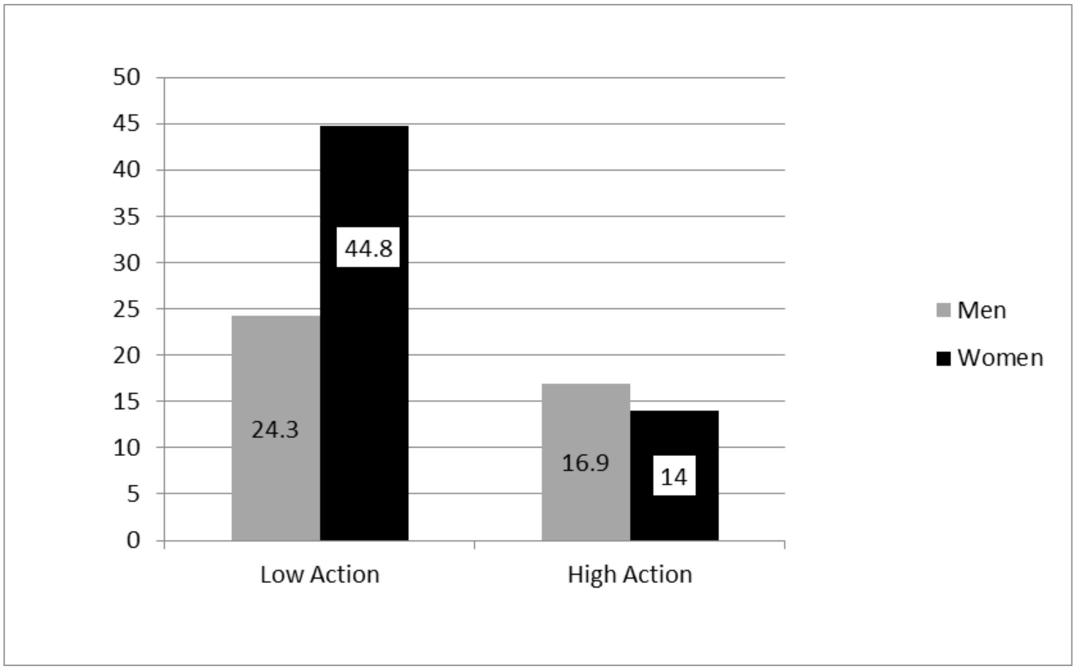

Figure 3-3. Low action group of teacher compared with the high action group teachers as categorized by gender after training.

With respect to age, the highest odds of teaching behavior are seen among baby-boomer and generation ‘x’ teachers. The odds of being in the high action teaching group for a baby boomer was 10.19, while for a generation ‘x’ teacher was 8.10 times higher than a millennial generation teacher, regardless of gender. The odds of being in the low action teaching group increased substantially if a teacher was from the millennial generation. Less than 2% of teachers from millennial generation actually taught material that they acquired during the training.

3-4.4 Past behavior, FARM, and State

Past behavior played a significant role in determining the teaching behavior, wherein teahers who had not engaged in ESB in classroom teaching in the past were 0.3 times less likely to engage in teaching behavior when compared to teachers who done so. The odds of being in the high action teaching group decreased 0.46 times for teachers that had rarely taught these topics as compared to the teachers who had taught them frequently. Participation in federal Free and Reduced Meal (FARM) program did not change teaching behavior (i.e., low or high income districts, public versus private) and the length (i.e., 3 weeks versus 1 week) of the training had no effect on increasing the likelihood of a teacher undertaking behavior that engaged topics directly on renewable energy and sustainability. I found a similar lack of changes in the teaching behavior across all participating states and the location of the school districts.

3-4.5 Relationship between RAA variables and teaching behavior

I found that teachers' pro-environmental attitudes were not significant in predicting teaching behavior. That is, the odds of being in a high action teaching group remain unchanged in the presence or absence of pro-environmental attitudes. However, *pro-energy attitudes increased likelihood of teaching behavior*. *Specifically, positive attitudes on renewable energy were 1.28 times more likely to place a teacher in the high action teaching group with or without training.* I further found that pro-energy attitudes along with normative beliefs increased the overall likelihood of teaching behavior. Normative beliefs in favor of teaching were 1.18 times more likely to predict teaching behavior, but normative beliefs about energy were not predictive (Table 3-5). Teachers' behavioral beliefs, control beliefs, and norms were not significant predictors however, PBC and internal LOC were significant in predicting teaching behavior. The odds of being placed in the high action teaching group increased 1.47 times in the presence of internal LOC, while PBC increased the teaching behavior by 1.07 times.

Overall, I report conflicting evidence of the RAA model's ability to predict teaching behavior. The effects of environmental attitudes, control beliefs, behavioral beliefs, norms, locations of schools, and states were not significant in determining teaching behavior. However, teaching behavior was associated with increased PBC (i.e. Internal LOC) and normative beliefs. In summary, teaching behavior was most dependent on extrinsic factors such as age, gender, past behavior of participants, and group size during training along with the teachers' energy attitudes.

3-5 Discussion

3-5.1 Effect of social-demographic variables and training

The strongest predictor of teaching behavior was teacher age and gender. Male teachers were 2.62 times more likely to engage in the teaching behavior than female teachers. Gender also played a significant role in the choice of topics teachers elected to teach. Both men and women teachers taught climate change, renewable energy systems, and energy savings, but the topics that were emphasized in the training program (i.e. bioenergy, bioproducts, and biomass crops) were taught mostly by men. Furthermore, men reported having taught wind, nuclear, and solar energy more often than women teachers.

Increased familiarity with the subject matter of renewable energy, environment, and sustainability was associated with an increased teaching behavior (Appendix 3-1a). It is likely that increased knowledge stimulated the high action group of participants to teach and, thereby, engage in ESB in their classrooms (Appendix 1a) when compared to the low action participants. Men rated themselves as more familiar than compared to women teachers. Few studies have focused on gender differences and knowledge, although studies found similar gender-based differences in knowledge (Liarakou, Gavrilakis, and Flouri 2009; Zyadin, Puhakka, Ahponen, and Pelkonen 2014). Prior studies suggested that men report themselves as more knowledgeable, but women expressed more concern about the issues (Arcury, Scollay, and Johnson, 1987; Grieve and Van Staden, 1985; Schahn and Holzer, 1990; Stern, Dietz, and Kalof, 1993). But future study needs to examine gender-specific differences in reported knowledge, concern, and behavior at these training programs.

Extrinsic motivators, such as principal support and student interest, influenced women teachers, but not male teachers. Furthermore, women teachers expressed greater likelihood in teaching behavior if the topics were required under a wider school initiative or when the principal or superintendent placed a requirement to teach, but neither of these influenced male teachers. Several studies have suggested that administrative support is a barrier in implementing environmental education in classroom (Ernst, 2005). Future work should assess if presence of administrative support disproportionately affects more women teachers than male teachers.

Age was one of the largest predictors of odds of teaching behavior. Older teachers were far more likely to teach than younger teachers. I found that baby boomers and generation ‘x’ were 10.19 times and 8.10 times more likely than a millennial teacher to be in the high teaching group. There is limited evidence on age and teaching in the classroom. But, a longitudinal study from education literature suggests teacher effectiveness and motivation to teach plateaus after the first five years’ (Clotfelter, Ladd, and Vigdor, 2007). Because the increased likelihood of teaching behavior was associated with boomer generation and generation ‘x’ teachers, more studies need to look at efficacy of teaching across these generations. One likely explanation of this age effect is that most of the teachers in this study were from NY, DE, and MD (51.9%, 16.0%, and 15.6% respectively). At the time of the survey in 2012-2013, DE, MD, and NY had increased pressure on teacher evaluations and reporting, because of the implementation of state standards and common core curricula (Ballou and Springer 2015). Because these three states accounted for 83.8% of total participants, it is possible that tenured, older teachers were less risk-averse in implementing a topic that was outside of their stated curriculum, such as climate change or types of renewable energy.

I postulate that risk-aversion can lead younger or untenured teachers to avoid teaching these topics, despite their training. Teachers in unsecure teaching position tend to be risk-averse (Flyer and Rosen, 1997). Given the increased emphasis on charter schools in the United States (Renzulli and Roscigno 2005), I suggest that more research should be done to evaluate whether untenured teachers who engage in greater risks that are associated with alternative teaching methods and topics are less likely to adopt topics that may not be part of the required curriculum. Alternatively, it may be that older, tenured teachers are simply more experienced and, thus, they are better able to incorporate newer topics and activities in their classrooms (Carroll, Reichardt, Guarino and Mejia 2000).

Lack of training has been stated to be a barrier to teachers that prevents incorporating environmental education in their classrooms (Ham and Sewing, 1988; Lane, Wilke, Champeau, and Sivek, 1994). But I found that the odds of being placed in the high action teaching group do not differ following the training. This finding conflicted with prior work that suggested that EE programs that are well integrated within classroom curriculum could support environmental literacy and pro-environmental behavior (Chawla and Cushing 2007; Monroe 2003). It has been suggested that many EE programs fall short in reaching desired learning objectives to increase environmental consciousness amongst their students (Sanera 1998; NAAEE 2010). Recent work on an integrated, environmental educational training program for pre-service teachers has also shown mixed results, wherein the program did not impact teachers' self-efficacy or outcome expectancy (Moseley, Reinke, and Bookout 2002).

Trained and untrained teachers did not differ in their teaching behavior. One potential reason could be administrative support at schools. This coupled with the constraints discussed before due to implementation on common core standards could have resulted in the current findings. Future work could verify the effect by utilizing a quasi-experimental control design in evaluation of EE training programs, a superior approach to one-group pretest-posttest design models that are currently widely utilized.

Environmental education programs are often assumed to be inferior to standardized traditional classroom curriculum and thus administrative support from principals for integrating such programs into mainstream educational systems remains limited (May 2000; Athman and Monroe 2001; Palmer 2002; Carleton-Hug and Hug 2010; Potter 2009). Other problems could include the age of the teachers, the priorities of the funded program, or the construction of appropriate evaluative tools that could measure such differences accurately (Duffin, Murphy, and Johnson, 2008; Short, 2009). A more detailed summary of measurement problems was discussed previously by Heimlich (2010). Sanera (1998) found that most EE materials were erroneous in their content, and failed to provide an adequate framework for knowledge construction (Dimanche 1990; Jacobson 1991).

Lack of adoption of teaching the EE curriculum may have resulted from contextual factors that were unique to each school district. The school climate is thought to play a role in trained teachers' adoption of teaching certain topics (May, 2000). The implementation of nationwide common core standard could also be one of the reasons for the lack of teaching topics such as environment, sustainability, and renewable energy, which are often not required to be part of the curriculum. However, given the lack of state level effects, the lack of adoption is more likely due to other factors. The support of other teachers within their school was a significant factor in mediating whether teachers continued teaching behavior after training (Table 3-6). Guidelines on developing energy curricula have stated the need for peer-to-peer teacher support that helps structure curricula, and to allow teachers to understand student motivations (Kirwan 2014).

Most surprisingly, teachers report that having access to visual aids is a deciding factor in their ability to teach environment, energy, and related topics. The need to have visual aids was significant compared to having structured lesson plans across gender and age groups, and across training time. Teachers can become increasingly discouraged when not given support to expand use of EE through training or curriculum development (May, 2000). It is also plausible that teachers felt discouraged in implementing much of the materials. The current work did not examine these reasons.

Overall, group size had a significant effect on teaching behavior. Teachers in groups smaller than six individuals were 0.07 times less likely to teach than teachers who were trained in larger groups, which was contrary to earlier findings that suggested that smaller group size was more effective (Glass, Cahen, Smith, and Filby, 1982; Riggins, 1986; Walsh and Golins, 1976). Many of these studies relate to youth and perhaps do not translate readily to the current study with adult population. However, some of the outdoor education research has shown evidence that smaller group sizes were more favorable for attaining positive outcomes within such groups (Deane and Harré 2014). However, some studies have shown that larger group size resulted in an increased degree of awareness and learning (Neil, 2004; Stern, Powell, and Ardoin, 2008). More work needs to conducted that examines closely if the increase in group size allows teachers to share their experiences of what works in their classrooms with others teachers such that they can gain from such shared experiences. I posit that shared experiences are more likely to occur within a larger group size.

3-5.2 RAA and teaching behavior odds

Although pro-energy attitudes made a teacher 1.23 times more likely to engage in ESB, I did not find any similar effect of pro-environmental attitudes in determining the odds of teaching behavior. <u>*This implies that there is a tethering of attitudes to energy and environment that may be based on two different value systems.*</u> A more recent study provided evidence for the existence of multiple domains within pro-environmental behavior and stated that these domains 'cannot (and should not) be measured using an aggregated or uni-dimensional scale' (Larson, Stedman, Cooper, and Decker, 2015). A recent policy brief found that attitudes about environment were a continuum, and that they fell into nine archetypes across a spectrum (Leiserowitz and Young, 2015). This work adds further evidence to the current finding that shows that energy attitudes and environmental attitudes are distinct domains.

In this study, attitudes towards environment and normative beliefs toward energy both lacked predictability in affecting teaching behavior that engaged both environment and energy. Environmental attitudes and protection of nature may, in fact, be two distinct domains (Kaiser, Hartig, Brügger, and Duvier 2011). Hines, Hungerford, and Tomera (1986) found weak to moderate correlations between positive environmental attitudes and pro-environmental behavior. But the cognitive aspects, such as knowledge of the issue and action strategies, interacted significantly with attitudes. I also showed environmental attitudes did not Table 6) drive behavior of teachers to teach topics related to the environment. Further research needs to verify divergence of energy and environmental attitudes and their prediction of behavior. Specifically, environmental and energy training programs should focus not just on environmental attitudes as is done currently, but on attitudes that relate to energy itself. This is important since energy attitudes are often grouped along with environment in any EE program. While this may not represent a problem for teachers that are already pro-environmental, it could dissuade pro-energy teachers from adopting a curriculum that they view to be overly pro-environmental. I argue that it is important to reach a larger group of teachers to increase impact through EE program than simply focusing on a unique set of pro-environmental attitudes within teachers.

Next, I found evidence that PBC increased the odds of teaching behavior. In the presence of PBC, the reported teaching behavior odds increased 1.07 times (Table 9). Thus, internal LOC predicted psychological empowerment when other factors were considered in the model. These results are consistent with prior work that found an internal LOC contributed to psychological empowerment (Simoni, Larrabee, Birkhimer, and Mott, 2004). Luo and Tang (2003) found that individuals with greater internal LOC displayed higher psychological empowerment when compared with individuals with an external LOC. Increased empowerment of teachers has been shown to give them greater confidence in teaching skills, a greater determination to work, and a sense of responsibility (Wilkinson, 1998). Locus of control and individual sense of responsibility are important to individual willingness to undertake a behavior (Ajzen 2002).

Past behavior was a significant predictor of teaching behavior. The RAA theory has been shown to weaken considerably in its predictability with the inclusion of past behavior in the model (Bagozzi, 1981; Bagozzi and Kimmel, 1995; Norman and Conner, 1996). I found that for teachers who engaged in teaching behavior infrequently in the past, the odds ratio dropped 0.31 times when compared to teachers already engaged in the teaching behavior. Past behavior and habits have been shown to be one of the key determinants that influenced future behavior (Knussen, Yule, Mackenzie, and Wells 2004).

I found that normative belief was a positive determinant for teachers to engage in ESB, and that their attitudes about energy, past behavior, age, and gender played the most significant role in their ESB in classrooms. The final determinants of any behavior according to RAA are behavioral beliefs that surround the behavior and normative beliefs of others (Ajzen and Fishbein, 1980), and self-efficacy (Bandura, 1997). I further add evidence to current body of theoretical work that shows non-cognitive skills such as PBC can positively influence teaching behavior.

3-5.3 Conclusions and recommendations

The relationship between education and environmental attitudes ~~values~~ remains a contested topic of research (Kolmuss and Agyeman, 2002). I showed that attitudes toward energy played a greater role than environmental attitudes in the odds of a teacher adopting ESB teaching behavior. *Most importantly, I show that a teacher that is less environmentally-minded is just as likely to teach about renewable energy and related topics on environment as a pro-environmentally minded teacher*. Curriculum-based instruction on environment and climate change, for example, might be necessary, but it is often not sufficient for imparting responsible social and environmental values. Environmental education must engage individuals cognitively if they are to engage in ESB. A gap remains in research that analyzes empirically across samples whether education can trigger a change in environmental norms, values, and behavior. I have demonstrated that the current body of work lacks a fuller understanding of underlying attitudinal reasons that are instrumental in shifting ESB for teachers (i.e., adults).

Effective training must enable and motivate teachers' desire and ability to teach. Overall, the current learning processes of training programs are more instrumental than social. They usually disseminate results and decisions to funding agencies, but rarely do the training programs seek to engage participants within a social learning format to solve problems or to build intellectual capacity for collective learning (Armitage, Marschke, and Plummer, 2008; Wals et al., 2009). Prior studies have shown if individuals are engaged personally, and they feel responsible for being engaged with the environment, then these individuals are more likely to display responsible environmental behavior (Kaiser and Shimoda, 1999; Kollmuss and Agyeman, 2002; Stern, 2000). However, the focus of training programs often is a short-term engagement and any long-term engagement and follow-up is curtailed for a variety of reasons.

Lastly, I suggest training programs, funding agencies, and school administrations should cast a wider net for all types of attitudinal dispositions within participants, not just the attitude of being pro-environmentally minded, to engage in teaching environment, energy, and sustainability. A recent study that examined teachers in all 50 states showed that the political ideology of teachers was one of the strongest predictors of whether they taught topics that were culturally sensitive, such as climate change (Plutzer, McCaffrey, Hannah, Rosenau, Berbeco, and

Reid, 2016). I propose given the findings that renewable energy is a similar topic that is also culturally sensitive. It has been shown that often there is rejection of scientific conclusions on topics such as climate change when it is rooted in values (Kahan, 2015). Bioenergy (which was the focus of the training program) is one such topic that garners strong reactions. Thus, educational training programs should be accompanied with a higher level of engagement that utilizes social leaning experiences. Such shared experiences may reduce the focus on content knowledge at these training workshops and allow teachers to build collective knowledge through shared experiences, which may reduce barriers that prevent teachers from engaging in ESB as it relates to teaching environment and related topics.

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Appendix

Table3-1a: Reported knowledge level (%) in teaching materials by education level and gender

Education Level		Not at all/Very Little Knowledge	Somewhat Knowledgeable	Knowledgeable	Extremely Knowledgeable	Total
Some College/Other Post-High School	Women	0.5	0.5	0.0	0.0	0.9
	Total	0.5	0.5	0.0	0.0	0.9
Completed 4-yr College	Men	0.5	1.4	2.8	0.0	4.7
	Women	1.9	2.8	5.6	0.0	10.3
	Total	2.3	4.2	8.4	0.0	15.0
Graduate Work or Degree	Men	0.9	12.1	12.1	3.3	28.5
	Women	7.5	15.9	19.6	1.4	44.4
	Total	8.4	28.0	31.8	4.7	72.9
PhD or Advanced Grad Degree	Men	0.0	1.4	6.1	0.5	7.9
	Women	0.0	1.9	1.4	0.0	3.3
	Total	0.0	3.3	7.5	0.5	11.2
Total	Men	1.4	15.0	21.0	3.8	41.1
	Women	9.8	21.0	26.6	1.3	58.9
	Total	11.2	36.0	47.7	5.2	100.0

Table 3-1b: Chi-Square test between gender and reported knowledge levels

Chi-Square Tests			
	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.343[a]	4	.003
Likelihood Ratio	18.876	4	.001
Linear-by-Linear Association	8.576	1	.003
N of Valid Cases	214		
a. 3 cells (30.0%) have expected count less than 5. The minimum expected count is .41.			

CHAPTER 4:

ATTITUDINAL AND EDUCATIONAL DRIVERS OF ENVIRONMENTALLY SIGNIFICANT BEHAVIORS IN K-12 STUDENTS

Abstract

Knowledge is the most commonly measured outcome in the review of environmental education work, followed by attitudes. Limited work, however, has engaged how youth acquire environmental attitudes under a quasi-experimental condition. This study used the theory of planned behavior (TPB) to identify the attitudes that influence K-12 students' (grades 8-12) intent to perform environmentally significant behaviors (ESB). This research takes a closer look at the relationship between the role of knowledge and ESB. Students were surveyed before and after an intervention that consisted of education about renewable energy and environment. Students completed a questionnaire early in the school year and toward the end of the year, well after the intervention (n=1,403). In addition to the TPB constructs, the pre-post questionnaire assessed four types of attitudes (energy, ecocentric, anthropocentric, and affective). Examination of the four-attitudinal types revealed that affective, ecocentric, and anthropocentric attitudes were central in predicting behavioral intent in youth. Perceived behavioral control and affective attitudes were the most significant predictors of student intent to engage in ESB. Norms, behavioral beliefs, and control beliefs also contribute to an increase in the likelihood of students engaging in ESB.

Keywords: *'Renewable energy'; 'environmentally significant behavior'; 'Students'; 'environmental education'; 'environmental attitudes'; 'behavior'*

4-1 Introduction

Any response to environmental threats must involve today's youth because they are the generation who have the most to gain or lose depending on whether these problems can be stemmed. However, youths are also less likely to engage in environmentally significant behaviors (ESB) (Grønhøj and Thogersen, 2012; Johnson, Bowker, and Cordell, 2004). A recent longitudinal analysis of high school seniors from 1976 to 2005 with data from the Monitoring the Future study revealed that youths' concern for the environment was declining (Wray-Lake, Flanagan, and Osgood, 2010). Past research on how youths respond to ecological problems has shown mixed responses. Some studies have shown that youth respond with civic engagement and a sense of personal responsibility (Gullan, Power, and Leff, 2013; Johnson, Johnson-Pynn, and Pynn, 2007), although others have shown a denial of these problems (Doherty and Clayton, 2011) or a lack of interest (Reser and Swim, 2011). Data from numerous countries indicate that young people would like to respond to environmental problems with minimal levels of inconvenience, with individual solutions (e.g. turning off lights, unplugging cell phone or recycling) (Rodriguez, Boyes, Stanisstreet, Skamp, and Malandrakis, 2011). Thus, understanding what motivates today's youth to engage in ESB is important, and it could facilitate the creation of educational interventions (Gifford, Steg, and Reser, 2011). Much of the work discussed above and preceding this section will discuss attitudes and behaviors as types of responses.

4-1.1 Environmental education and environmentally significant behavior

The desire for ESB has prompted policy makers, NGOs, and government agencies to design and implement educational efforts in this area. Environmental education (EE) has been defined as a process that leads to increased awareness and sensitivity to the environment and to an increased knowledge and experience of environmental problems (UNESCO, 2002). Others have defined EE as process that leads to an increase in pro-environmental attitudes and skills to identify and reduce environmental threats (Jacobson, McDuff and Monroe, 2006). EE is promoted typically to influence and engage ESB (Heimlich 2010; Hungerford and Volk, 1990; Monroe, 2003) by increasing knowledge and changing attitudes (Kaiser, Oerke and Bogner, 2007). However, evaluations of EE effectiveness have shown that changes in environmental attitudes and behaviors with EE can be inconsistent with the program objectives (e.g. Carleton-Hug and Hug, 2010; Feinstein, 2009; Keene and Blumstein, 2010; Meyers, 2006; Rickinson, 2001). Awareness of environmental problems and its consequences is also inadequate in prompting ESB or pro-environmental attitudes (Bamberg and Möser, 2007; Hungerford and Volk, 1990; Kollmuss and Agyeman, 2002; Schahn and Holzer, 1990).

4-1.2 Environmental and anthropocentric attitudes

Environmental attitudes have been defined as "the collection of beliefs, affects, and behavioral intentions a person holds regarding environmentally related activities or issues" (Schulz, Shriver, Tabanico, and Kazian, 2004, p. 31) alternatively they could be simply defined as an individual's concern for the physical environment. Dietz, Fitzgerald, and Shwom (2005) have described environmental attitudes to be rooted in either a concern for all living things (ecocentric concern) or in a concern for humans (anthropocentric concern). Anthropocentric orientations in people make them less likely to actually act upon their values, attitudes, and beliefs when compared to ecocentric attitudes (Kortenkamp and Moore, 2001; Karipak and

Baril, 2008). Ecocentric and anthropocentric attitudes differ in how individuals express their attitudes towards the environment. An Ecocentric attitude focuses on attitudes that value nature itself, while anthropocentric attitudes value nature based on the inherent utilitarian value of nature for humans (Thompson & Barton, 1994). Thus, ecocentric positions tend to occur along with anthropocentric positions (Dietz and Shwom, 2005) and collectively as environmental attitudes they inform an individuals' environmental concern.

4-1.3 Environmental concern, energy attitudes and affective attitudes

Human behavior and thereby environmental concern is integral to the production and the use of energy, which often contributes to environmental problems (DuNann Winter and Koger, 2004, Steg and Vlek, 2009; Gillingham and Newell, 2009). Environmental concern began as an attempt to measure public concern for environmental quality (Weigel and Weigel, 1978). Environmental concern was used broadly to establish concern about pollution and the use of natural resources (Van Liere and Dunlap, 1981). Environmental concern and environmental attitudes are often used interchangeably in environmental education literature (Fransson and Garling, 1999; Dunlap and Jones, 2003). Environmental attitudes are frequently included in explanatory models to explain energy-related behavior. The determinants of environmental concern have not been able to explain renewable energy attitudes (Petrova, 2010). This is because the relationship between environmental concern and renewable energy development has proven to be somewhat complex (Devine-Wright, 2007). Furthermore, attitudes towards renewable energy have complexity in which environmental attitudes could be distinct from renewable energy attitudes.

4-1.4 Environmental attitudes and environmentally significant behavior

Environmental attitudes have been stated to be a "powerful predictor of ecological behavior" (Kaiser, Ranney, Hartig, and Bowler, 1999). But, the relationship between environmental attitudes and ESB is often weak (Hungerford and Volk 1990; Kals, Schumacher, and Montada 1999; Kaplan and Kaplan 1989; Kempton, Boster, and Hartley 1996; Kollmuss and Agyeman 2002; Müller, Kals, and Pansa 2009; Schahn and Holzer 1990). The most extensive review on the relationship between environmental attitudes and ESB over 30 years ago found weak to moderate correlations between positive environmental attitudes and pro-environmental behavior (Hines, Hungerford, and Tomera, 1986). More recent reviews have shown that in combination with attitudes, behavioral control and personal moral norms are good predictors of ESB (Bamberg and Moserr, 2007). Most current meta-analyses showed environmental attitude, personal norms, perceived behavioral control, and social norms collectively predict the intent to engage in ESB (Klockner, 2013). The predictability associated with environmental attitudes towards ESB is complicated, because they influence beliefs, personal norms, perceived behavioral control, and social norms. Thus, ESB has multiple antecedents (Stern and Dietz, 1994; Stern, Dietz, Kalof, and Guagnano, 1995; Thompson and Barton, 1994), of which environmental attitudes are just one.

4-1.5 Measurement of environmental attitudes

Measures of environmental attitudes are numerous (Dunlap and Jones, 2002), and continue to proliferate (Milfont and Duckitt, 2004), leading to an ''anarchy of measurements'' (Stern, 1992, p. 279). Environmental attitudes have been viewed as a unidimensional construct and, as such, have been measured accordingly as exemplified in the New Environmental Paradigm (NEP) scale (Dunlap and Van Liere, 1978; Dunlap, Van Liere, Mertig, and Jones, 2000). Schultz (2000, 2001) later suggested three corollary factors that affected environmental attitudes: concern for the self (egoistic), concern for other people (altruistic), and concern for the biosphere (biospheric). But viewing environment in one dimension has provided little explanation for the resulting environmental attitudes (Costarelli and Colloca, 2007). There have been few attempts to understand the multidimensional and hierarchical nature of environmental attitudes (Heberlein, 1981; Milfont and Duckitt, 2004).The existence of multiple dimensions of environmental perception can contribute to varying degree of environmental attitudes, which in turn can motivate or dissuade ESB. It is therefore crucial to understand the dimensionality of environmental attitudes in order to accurately predict ESB.

4-1.6 Relationship between environmental attitudes, energy attitudes and behavior

Understanding youths' environmental attitudes is necessary to evaluate and improve EE programs that target ESB (Kruse and Card, 2004; Leeming, Dwyer, and Bracken, 1995). Few studies have assessed youth environmental attitudes and ESB (Bamberg and Moser, 2007; Gifford and Nilsson, 2014), but there have been abundant studies, which have examined pro-environmental attitudes during childhood (Larson, Green, and Castleberry, 2011; Manoli, Johnson, and Dunlap, 2007). This scarce scholarly attention contrasts with the need to comprehend how youth think and feel about environmental issues and problems (Cheng and Monroe, 2012; Collado, Staats, and Corraliza, 2013; Evans, Juen, Corral-Verdugo, Corraliza, and Kaiser, 2007). Focusing on youth is even more important, given that worldviews are still forming during this time (Vollerberg, Iedema, and Raaijmakers, 2001). If we are to succeed in creating, sustaining, and engaging youth to be active environmentally through EE, then we need to identify if environmental attitudes promote the adoption of ESB.

Environmental attitudes have been shown repeatedly in large meta-analysis to predict ESB (Bamberg and Moserr, 2007; Klockner, 2013). Prior work has examined environmental attitudes in youth exclusively as ecocentric and anthropocentric attitudes (Ewert, Place, and Sibthorp, 2005; Kopnina, 2014). Energy attitudes in youth have largely been surveyed as energy literacy based attitudes (DeWaters, and Powers, 2008) or specifically as bioenergy (Halder, Havu-Nuutinen, Pietarinen, and Pelkonen, 2011). Currently, we do not have a clear understanding of key attitudes in relation to ESB among youth in a K-12 school setting as it pertains to renewable energy. No study prior to this has measured ecocentric attitudes, renewable energy attitudes, affective attitudes, and anthropocentric attitudes simultaneously. Furthermore, to this date renewable energy attitudes of youth have not been assessed separately from environmental attitudes or affective attitudes.

4-2.1 Rationale and study focus

To fill this gap, I conducted a study based on the theory of planned behavior (TPB) to understand the behavioral intent of youth to engage in learning about renewable energy. Certain behaviors, such as disposing waste or recycling, directly cause environmental change and are therefore a direct form of ESB. I focus on indirect ESB, these are behaviors are indirect because they shape the context in which choices are made which can then directly influence environmental change (Rosa & Dietz, 1998).

I propose that learning about renewable energy and environment is a form of indirect ESB. It is indirect, because learning about renewable energy and environment can influence the context under which a student may decide to engage in more direct ESB that pertains to these topics. More importantly, indirect engagement with renewable energy and environment can also affect student attitudes (i.e. affective, renewable energy, anthropocentric, and environmental attitudes) towards ESB. These attitudes can in theory affect the underlying beliefs that students have towards renewable energy and the environment. For example, if the indirect engagement were overall favorable then the student is more likely to engage in ESB. However, if the student associates learning with negative consequences, then they would have unfavorable attitudes and, thereby, are less likely to engage in ESB.

A student's perceived control on these engagements is a result of control beliefs, which are perceptions that facilitate or impede their learning and, thus, increase or decrease behavioral intent towards ESB. Lastly, norms have been studied extensively using TPB and they provide an understanding of ESB (e.g., Cialdini, 2001; Cialdini and Goldstein, 2004; Kallgren, Reno, and Cialdini, 2000; Onwezen, Bartels, and Antonides, 2014). Given the age of the students, descriptive norms may matter less than injunctive norms. Injunctive norms are based on their perception of what important referents (e.g., parents, teachers, friends, and family) think about what they are supposed to do; descriptive norms are based on beliefs that concern these referents' own behavior toward renewable energy (Rivis and Sheeran, 2003).

4-2. Theoretical Underpinning

4-2.1 Theory of planned behavior

In the present study I utilized the theory of planned behavior (TPB) to understand BI of K-12 youth toward renewable energy and learning. TPB suggests that behavioral intentions (BI) serve as direct predictors of ESB as does perceived behavioral control (PBC). PBC refers to the assessment by individuals of their ability regarding the difficulty/ease in performing a given behavior. The TPB states that favorable attitudes towards ESB should increase the BI.

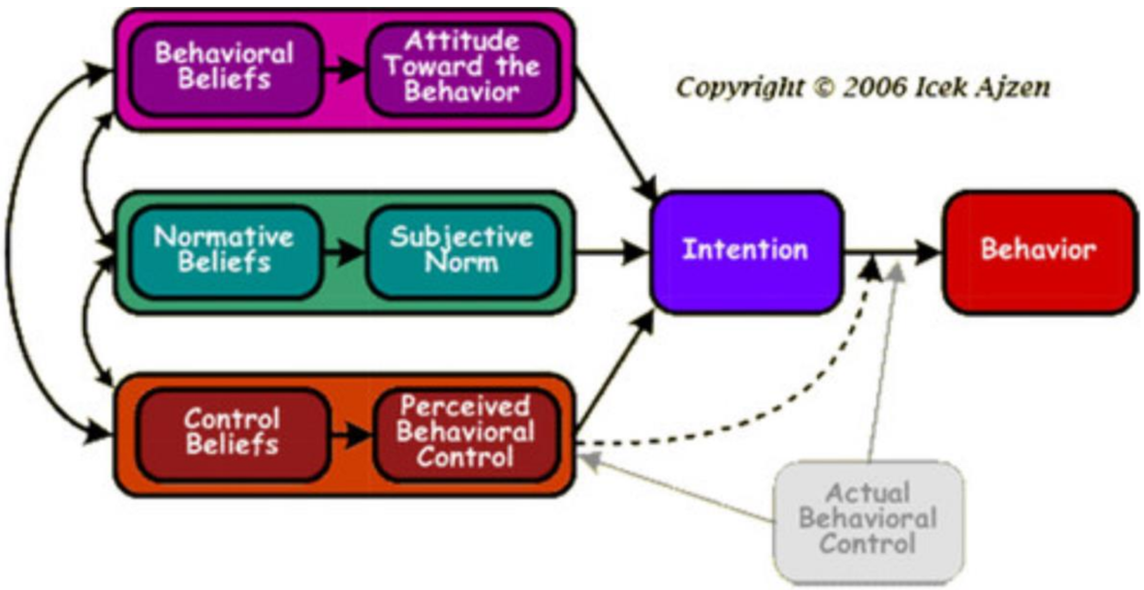

Figure 4-1: Schematic representation of the theory of planned behavior.

Normative referents (i.e. significant others), injunctive norm (i.e. support for such behavior) and descriptive norm (i.e. adopt the behavior themselves) mediate BI towards ESB and most importantly, if an individual perceives to have control over action then BI and ESB should follow (Figure 4-1, above)(Note: Please refer to sections 1-1.5-1.8 in chapter 1 for the theoretical basis and perspectives of TPB as well as a detailed discussion on it its limitations). Ajzen (1991) suggests three salient beliefs, (1) behavioral beliefs, which influence attitudes towards the behavior; (2) normative beliefs, which constitute the underlying determinant of subjective and injunctive norms; and (3) control beliefs which provides the basis for PBC. Beliefs in aggregate will produce a favorable or unfavorable disposition toward the attitude and one's attitudes about a behavior are evaluated within the context of subjective norms and perceived behavioral control (Ajzen, 1991, 2005). Most importantly, attitudes themselves are based on behavioral beliefs about the likely consequences of the ESB.

The theory of planned behavior (TPB) has been used extensively to explain a variety of environmental behaviors, such as recycling (Kaiser and Gutscher, 2003), composting (Mannetti, Pierro, and Livi, 2004; Taylor and Todd, 1995), choice of travel mode (Bamberg and Schmidt, 2003; Heath and Gifford, 2002), purchasing of energy-efficient appliances (Harland, Staats, and Wilke, 1999), water conservation (Trumbo and O'Keefe, 2001), and generalized pro-environmental behavior (Kaiser, Wölfing, and Fuhrer, 1999). Most importantly, meta-analysis across different behavioral domains supports the role of norms as a significant predictor of intention (Rivis, Sheeran, and Armitage, 2009). The same conclusion emerged in other meta-analyses that have shown that norms, attitudes, and PBC serve as significant predictors of BI (Bamberg and Moser, 2007; Hines et al., 1986; Klockner, 2013).

4-2.3 Research purpose and question(s):

This work is part of a larger research project that examines the effects of energy and environmental education on K-12 teachers and students across Northeast, Mid-Atlantic, and Midwestern U.S. schools. The primary aim of this research is to assess if intervention of education in youth (Grades K-8 through12) results in changes in behavioral intent (BI) towards ESB in youth. A second aim was to assess if there were differences in students' BI intent towards learning about environment and renewable energy based on the intervention of having been taught those topics). The third aim was to examine the effect of attitudes, specifically environmental, energy, anthropocentric, and affective attitudes, on students' reported BI toward renewable energy and associated ESBs. Accordingly, the following hypotheses were developed:

I. Education about the environment, sustainability, and renewable energy will increase students expressed BI to undertake ESB.

II. In accordance with TPB, (a) positive beliefs towards renewable energy and (b) pro-environmental attitudes will increase the likelihood of students wanting to learn more about those topics leading to an increase in ESB.

III. Expressed BI after learning about environment and renewable energy will increase given pro-energy attitudes, anthropocentric, and affective attitudes.

4-3 Methods

4-3.1 Research context

The study was situated within a national teacher training program, which is a consortium of nine institutions of higher learning in the Northeastern US that provides professional development workshops to (STEM)+ Agriculture teachers, grades 6 through undergraduate college level. Teachers from schools in Delaware (DE), Maryland (MD), New York (NY), Ohio (OH), and Pennsylvania (PA) participated in the in-service program. The emphasis at the training was to provide teachers with a systems perspective and learning-standard-ready teaching tools as they pertain to renewable energy, sustainability, and the environment.

4-3.2 Experimental design

Most EE research fails to utilize before and after, treatment-control designs. Moreover, there is a lack of empirical studies that assess the relationship between education and environmental attitudes under a quasi-experimental design in a K-12 setting within the U.S. Only 12 studies utilized a pre-post measure, but not under a K-12 setting (Stern, Powell, and Hill 2014). The inclusion of the control group, which allowed to test if the training intervention on environment and renewable energy had the hypothesized effect (i.e., whether the students of teachers who were trained expressed higher BI for ESB compared to students of teachers who had not attended similar workshops).

4-3.3 Data collection procedure

Data collection occurred during 2012-13 across five states: DE, MD, NY, PA, and OH. A survey instrument was administered to two groups of students at participating K-8-12 school districts: 1) students of trained teachers, 2) students of untrained teachers. The trained teachers' students (i.e., experimental group) were compared to untrained teachers' students (i.e., control group) from the same school district and within similar grade levels. The survey was administered to students in class, after obtaining their oral consent, using a paper-and-pencil format at the beginning of the school year (i.e., pre-intervention, n=1625) and post-intervention at the end of the school year in class, n=1587). Given the pre-post nature of the research design, I eliminated students that were absent the day of the survey for either the pre- or post-intervention survey, which resulted in a final sample of n=1498. Accounting for the pre-intervention sample size, I achieved a response rate of 92.2%.

4-3.4 Survey tool

The Theory of Planned Behavior (Ajzen, 1991) has not been used to evaluate attitudes about renewable energy in K-12 students. The survey was created, in part, by utilizing existing measures about students' perceptions and attitudes toward renewable energy (Halder et al, 2010), assessment of renewable energy (Minton and Rose, 1997), affective attitudes about energy (Stedman and McComas, 2010), and environmental concerns (NEP scale, Dunlap, 2000).

4-3.4.1 Pilot study and questionnaire development: The survey questions were developed in consultation with previous surveys on attitudes of students toward renewable energy. The final instrument was based on several rounds of pretesting and revised using comments from project staff, researchers in the field, past educators, and the Human Dimensions research group at Cornell University. For the pretesting, I administered the draft survey instrument to an 8th grade class. I asked them to circle questions that were difficult to understand, and to make notes on how to make improvements. After making adjustments to the wording of several items, I administered a second draft version of the survey to an additional two classes of middle and high school students and asked for written feedback from their teachers. Additionally, I conducted interviews with educators from the workshop to gather general feedback and to identify which questions and scales were easier to understand. In addition to the qualitative pre-testing, I tested each for normality of responses and reliability. Histograms revealed normal distributions for student responses to each scale that was included in the instrument draft.

4-3.4.2 IRB and the consent process: The final energy evaluation survey for assessing students' attitude towards renewable energy was developed and was approved by Cornell

University IRB (Protocol ID# 1105002254). Similar exemptions were also obtained from Ohio State University, Pace University, University of Maryland, and Delaware State University Office of Sponsored Programs and/or Institutional Review. Further, the participating teachers at the workshops and the control teachers (untrained) signed a written consent form that allowed us to contact each school district and, wherever needed and applicable, I obtained a further IRB exemption from the district superintendent. A week prior to the in-class survey, the teachers had informed parents of the survey with a one-page description of its contents and purpose, and this allowed students to opt-out should they wish.

4-3.5 Survey measures

Seven questions assessed participant characteristics: gender, race, school district, qualification, grade level, subject studied, and knowledge level on renewable energy and environment. The remaining items were developed from focus groups/elicitation interviews with educators. The survey instrument consisted of 48 items, which comprised 10 key elements: past learning behavior; behavioral, normative, and control beliefs on renewable energy teaching and adoption; students' personal preference for future energy sources; affective items; attitudes towards renewable energy; self-efficacy (PBC); pro-environmental attitudes, and ecological attitudes.

I utilized multi-item scales for each of the variables associated with TPB (see section 4-2.1). Behavioral belief was measured by assessing students' beliefs about the consequences of adopting ESB; normative belief was measured using injunctive normative belief, in which students were asked to indicate if peers (i.e., students), teachers, family, friends, and parents expected them to learn. All items were rated on a 5-point scale that ranged from very likely to very unlikely. Control beliefs were measured using specific control factors that would strengthen or weaken the ESB adoption. I also measured PBC, past behavior, and behavioral intent, and I measured affective (i.e., emotions), environment, and anthropocentric attitudes that were related to renewable energy, using a 5-point Likert scale.

The scale reliabilites for all constructs ranged between 0.68 and 1.00, which indicated acceptable reliability levels (Gliem and Gliem, 2003). Specifically, the scale reliability and the number of items for each constructs were as follows, behavioral intent (α= 0.91, items=9); past behavior (α=0.75, items=3); PBC (α=0.68, items=5); norms (α=0.69, items=6); behavioral beliefs (α=0.72, items=9); normative beliefs (α=0.79, items=6); control beliefs (α=0.69, items=6). The scale reliability (αs) for all attitudes measured was high, specifically, attitudes towards renewable energy (α=0.90, items=12); attitudes towards environment (α=0.99, items=4); anthropocentric attitudes (α=0.99, items=4); and affective attitudes (α=0.98, items=3).

4-3.6 Dependent variable

The dependent variable was behavioral intent (BI), as measured by summing the frequency of nine discrete items. These items measured expressed likelihood of students towards a range of items such as attend local public meetings, volunteer for an environmental group, talk with elected officials, posting something online, starting an energy club at their school or discussing it with parents, teachers, or friends. The objective here was to have the nine items that measure ESB spanning a range of difficulty levels for the students. For example, high difficulty items included items like starting a renewable energy club at school or going to talk with an elected official. While the lower difficulty items consisted of posting something online about the topic or talking with family about renewable energy and environment. BI was measured as a categorical response of ‘likely’ or ‘not likely’. More specifically, the survey instrument specifically highlighted a range of likeliness ranging from not likely, somewhat likely, and very likely, which was compared to a discreet choice of not at all likely. Thus, the students’ BI was categorized by giving a score of ‘0’ or ‘1’, and ‘0’ represented ‘not likely at all’ to engage in a specific ESB, while ‘1’ represented some level of ‘likeliness’ to engage in an activity.

4-3.7 Model specifications

TPB assumes that students decide whether to engage in ESB based on beliefs, norms, and attitudes. To the best of my knowledge, TPB and the four distinct types of attitudes of K-12 students have never been tested in this type of modelling. A binomial, logit (generalized linear model) was applied to determine the underlying factors that influenced BI for the students. Both independent variables such as pre versus post-intervention and attitudinal variables were used as explanatory variables to determine the underlying factors. The TPB variables included: past behavior, behavioral beliefs, control beliefs, normative beliefs, energy attitudes, ecocentric attitudes, anthropocentric attitudes, affective attitudes, norms, perceived behavioral control (internal and external), specific external variable controls that included grade level, gender, school district, and state.

The adopted approach relied on Odds ratios that were determined for each level of the independent variables in the models that were significant. Odds ratios refer to the likelihood of a students’ BI, given a particular characteristic of the student (e.g., being taught renewable energy and environment versus not being taught or being male versus female, etc.). The use of the odds ratio helps us to understand under what conditions would a student would be more likely to state an increased BI towards ESB. For this to occur, an examination of the full theoretical model was conducted which included all mediators within the TPB model as well as grade level, gender, school district FARM participation (income), state, and pre- versus post-intervention. All statistical analyses were conducted using SPSS (v. 24.0 and v. 23.0).

4-4. Results

4-4.1 Characteristics of study participants

The students attended diverse school districts across a range of family incomes (Table 4-1). Lower income districts participated in the federal Free and Reduced Meal (FARM) program. I was able to have more or less equivalent samples between the control (49.4%) and experimental groups (50.6%). I had similar race compositions in the sample as the 2010 census data for U.S. Specifically, the participant sample was composed of 65.1% white, 12.5% black, 5.3% Asian, 6.9% Hispanic, and 10.3% mixed race. The only race under-represented was Hispanic, which was 17% nationally. Multiracial students were overrepresented at 10.4%, given that the reported national average was 2.4%.[4] Most of the students (45%) were enrolled in a science class and the remainders were in environmental or earth science (30.4%), followed by a

[4] United States Census, 2012, National statistics for all states and counties, and for cities and towns with a population of 5,000 or more. https://www.census.gov/quickfacts/table/PST045215/00

Table 4-1. Participants' background and characteristics of students within the study and the frequency of sample within control and treatment population across characteristics (n=1403).

Student Background and Characteristics		N	Total Frequency (%)	Percentage (%) Control	Treatment
Treatment Group	Control	695	49.5	---	---
	Experimental	708	50.5	---	---
Type of School District	Public	1136	81.0	49.8	50.2
	Private	69	4.9	51.4	48.6
	Charter	198	14.1	46.5	53.5
Grade Level	8^{th}	241	17.2	52.5	47.5
	9^{th}	201	14.3	48.7	51.3
	10^{th}	210	15.0	44.5	55.5
	11^{th}	265	18.9	56.8	43.2
	12^{th}	486	34.6	44.3	55.7
School District Location	Urban	556	39.6	48.3	51.7
	Suburban	659	47.0	49.8	50.2
	Rural	188	13.4	43.9	56.1
Gender	Male	698	49.8	46.3	53.7
	Female	705	50.2	52.5	47.5
Race	White	912	65.0	46.8	53.2
	Black	175	12.5	51.4	48.6
	Asian	75	5.3	54.1	45.9
	Hispanic	97	6.9	70.1	29.9
	Multiracial	144	10.3	38.9	61.1
State	NY	733	52.2	49.9	50.1
	DE	175	12.5	50.9	49.1
	MD	172	12.3	41.8	58.2
	OH	246	17.5	48.8	51.2
	PA	77	5.5	45.5	54.5
Subject Area	Science	631	45.0	45.2	54.8
	Environment/Earth Science	426	30.4	42.3	57.7
	Math	12	0.9	100	---
	Language	126	9.0	48.0	52.0
	Technology	123	8.8	75.6	24.4
	Agriculture	85	6.1	48.9	51.1
	Total	1403	100.0		

language class (9.0%), technology (8.8%), agriculture (6.1%), and math (0.9%). Most of the students in the sample were from NY (52.2%), and the least representation was from PA (5.5%). The schools were predominantly suburban (46.9%) and urban (39.7%) school districts with fewer schools from rural districts (13.4%).

4-4.2 *Descriptive statistics*

The correlation matrix indicated that the independent variables in the TPB were all associated significantly with BI (Table 4-2). Affective attitudes were significantly correlated with all variables except for norms. Norms were not correlated with beliefs or attitudes. Participants reported low to moderate behavioral beliefs (*M=3.49, SD=. 55*), control beliefs (*M=3.51, SD=. 0.57*) and normative beliefs (*M=3.07, SD=. 56),* moderate ecocentric attitude (*M=3.72, SD=. 45*), low to moderate energy attitudes (*M=2.74, SD=. 54*), moderate affective attitudes (*M=3.11, SD=. 27*) and anthropocentric attitudes (*M=3.28, SD=. 40*). Ecocentric, anthropocentric, affective, and renewable energy attitudes were all similar across groups. The remainder of the variables were weak to moderate predictors, specifically, norms (*M=3.51, SD=* .57), past behavior (*M=2.39, SD=. 68*) and behavioral intent (*M=2.39, SD=. 68*). The results showed that all variables referred to different constructs, because their intercorrelations varied from only .48 to .08 (Table 4-2, next page).

I found no significant differences between control and treatment group within each of nine items that measured ESB of students prior to the intervention. However, I found significant differences between treatment and the control groups following the intervention. All BI items differed significantly between treatment and control in the post-test, except for asking the teacher

Table 4-2. Means, standard deviations and correlations between variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11
1.Past behavior[a]	2.39	0.68	1.00	.330**	.358**	.339**	.229**	0.03	.083**	.059*	.161**	.342**	.480**
2.Normative beliefs[a]	3.07	0.56	.330**	1.00	.931**	.422**	.406**	0.01	.066*	.126**	.269**	.392**	.403**
3.Behavioral beliefs[a]	3.49	0.55	.358**	.931**	1.00	.451**	.443**	0.01	.091**	.096**	.251**	.407**	.433**
4.Control beliefs[a]	3.51	0.57	.339**	.422**	.451**	1.00	.500**	0.00	.057*	0.04	.182**	.429**	.566**
5.PBC[a]	3.42	0.80	.229**	.406**	.443**	.500**	1.00	-0.05	.054*	0.00	.169**	.360**	.363**
6.Norms[a]	3.51	0.56	0.03	0.01	0.01	0.00	-0.05	1.00	0.01	0.00	0.00	0.02	.068*
7.Energy attitudes[a]	2.74	0.54	.083**	.066*	.091**	.057*	.054*	0.01	1.00	0.02	0.05	.131**	.135**
8.Anthropocentric attitudes[a]	3.28	0.40	.059*	.126**	.096**	0.04	0.00	0.00	0.02	1.00	.269**	.130**	.100**
9.Ecocentric attitudes[a]	3.72	0.45	.161**	.269**	.251**	.182**	.169**	0.00	0.05	.269**	1.00	.266**	.180**
10.Affective attitudes[a]	3.11	0.27	.342**	.392**	.407**	.429**	.360**	0.02	.131**	.130**	.266**	1.00	.433**
11.Behavioral intent (BI)[b]	2.39	0.68	.480**	.403**	.433**	.566**	.363**	.068*	.135**	.100**	.180**	.433**	1.00

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed).

[a] Scale of 1 to 5; [b] Scale of 0-4

to include more topics and talking with a family member (these were significantly different at p<. 05) (Table 4-3). Both items, talking with family (*M=2.29, SD=1.07*) or asking teachers (*M=2.09, SD=1.09*) (i.e., that more materials related to renewable energy and environment should be included) showed greater likelihood during the post intervention. Attending a public meeting on renewable energy and talking with an elected official were both lowest in pre and post intervention periods (i.e. attending public meeting was *M=1.64, SD=*. 66 and talking with an elected official was *M=1.59, SD=*.75 prior to the intervention while attending public meeting was *M=1.53,* was *M=1.59, SD=*.75 prior to the intervention while attending public meeting was *M=1.53, SD=*.74 and talking with an elected official was *M=1.5, SD=*.77 in the post-intervention stage. All items are described in Table 4-3 and Table 4-4a-b (next page and the following pages).

4-4.3 Intervention (pre and post), subject, and knowledge effects

I found no evidence that BI changed following the intervention. A single-sample t-test was conducted to compare BI for the students in intervention compared to the students in classes without the intervention. There was not a significant difference in BI between students in the treatment group (M=1.97, SD=0.87) and the control group (M=1.95, SD=0.89) [t (1402= 1.64), p>0.05]. Furthermore, both control and treatment groups of students reported an increased likelihood of undertaking ESB between time 1 and time 2. The increase across both control and treatment groups was following the intervention period, since prior to the intervention the two groups expressed similar likeliness to engage in specific ESB (Table 4-3).

Table 4-3. **Students' behavioral intent on renewable energy and environment before and after the intervention within control and treatment groups (n=1403)**

Description of ESB	Pre-Intervention						Post-Intervention			
	Control		Treatment		Total		Control		Treatment	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1.Attend public meeting	1.64	.65	1.63	.68	1.64	.66	1.48	.85	1.58	.74
2.Volunteer with environmental group	2.16	.97	2.12	.99	2.14	.98	1.70	.85	1.86	.85
3.Talk with elected official	1.58	.74	1.60	.76	1.59	.75	1.46	.70	1.60	.82
4.Join an online group	1.72	.86	1.74	.90	1.73	.88	1.50	.76	1.71	.89
5.Start a renewable energy club	1.64	.82	1.60	.79	1.62	.81	1.46	.75	1.59	.81
6.Ask teachers to include topics on energy	2.28	.99	2.24	.97	2.26	.98	2.03	.97	2.15	1.03
7.Ask friends about energy	2.05	.90	1.98	.92	2.01	.91	1.74	.86	1.88	.96
8.Post something online	1.98	.94	1.98	.92	1.96	.93	1.66	.84	1.84	.98
9.Talk to a family member	2.69	1.03	2.63	1.04	2.65	1.04	2.24	1.04	2.35	1.09
Mean and SD (total)	1.70	0.85	1.84	0.91	1.77	0.89	1.97	0.87	1.95	0.89

Note: all items scale ranged from 1 to 4

Table 4-4a. **<u>Students' attitudes on renewable energy and environment as measured and reported across control and treatment groups pre intervention (n=1403)</u>**

Key Survey Attitude Items	Control		Treatment	
	M	*SD*	*M*	*SD*
Anthropocentric Attitudes				
Decisions about energy left to private companies	2.39	1.18	2.33	1.17
Most energy problems solved with better technology*	3.49	1.11	3.46	1.13
Plant and animals for human consumption*	***1.94***	1.18	***2.07***	1.24
Environment protected even if it costs jobs	3.07	1.31	2.98	1.33
Affective Attitudes				
If or when I learn RE I feel happy	3.41	0.89	3.56	0.96
If or when I learn RE I feel pessimistic*	***2.5***	1.06	***2.58***	1.16
If or when I learn RE I feel enthusiastic*	***3.24***	1.04	***3.40***	1.12
I enjoy seeing Solar panels	3.38	1.21	3.54	1.20
Ecocentric Attitudes				
Ecological factors should guide use of natural resources *	3.38	1.10	3.29	1.11
We are approaching limit of number of people earth can support*	3.47	1.12	3.42	1.20
Earth has plenty of natural resources	3.97	0.99	3.89	1.08
Ecological crisis greatly exaggerated*	2.41	1.16	2.52	1.21
Renewable Energy Attitudes				
To me using RE is harmful/beneficial*	4.45	0.91	4.43	0.96
To me using RE is expensive/cheap	2.38	1.17	2.42	1.18
To me RE is efficient/inefficient*	***1.87***	1.06	***2.02***	1.10
To me RE is reliable/unreliable	2.26	0.94	2.32	0.97
To me RE is abundant/ scare	2.3	1.17	2.31	1.21

Table 4-4b. **<u>Differences in students' attitudes on renewable energy and environment across control and treatment groups post intervention (n=1403)</u>**

Key Survey Attitude Items	Control		Treatment	
	M	*SD*	*M*	*SD*
Anthropocentric Attitudes				
Decisions about energy left to private companies	2.39	1.05	2.38	1.18
Most energy problems solved with better technology*	***3.27***	1.1	***3.5***	1.12
Plant and animals for human consumption*	2.17	1.21	2.25	1.22
Environment protected even if it costs jobs	2.92	1.18	3.02	1.19
Affective Attitudes				
If or when I learn RE I feel happy	3.75	1.05	3.72	1.06
If or when I learn RE I feel pessimistic*	2.2	1.13	2.28	1.16
If or when I learn RE I feel enthusiastic*	3.61	1.07	3.63	1.05
I enjoy seeing Solar panels	3.92	1.04	3.86	1.08
Ecocentric Attitudes				
Ecological factors should guide use of natural resources *	***3.24***	1.03	***3.37***	1.07
We are approaching limit of number of people earth can support*	***3.23***	1.68	***3.54***	1.27
Earth has plenty of natural resources	3.72	1.17	3.66	1.15
Ecological crisis greatly exaggerated*	***2.77***	1.56	***2.67***	1.15
Renewable Energy Attitudes				
To me using RE is harmful/beneficial*	***4.26***	1.01	***4.42***	0.94
To me using RE is expensive/cheap	2.74	1.19	2.76	1.21
To me RE is efficient/inefficient*	2.08	1.08	2.10	1.24
To me RE is reliable/unreliable	2.39	1.12	2.27	1.11
To me RE is abundant/ scare	2.26	1.10	2.22	1.14

(all items scale 1 to 5), bold indicates significant differences for items at *=p<.05 level

I found students in treatment groups were 1.39 times more likely to engage in ESB related to renewable energy and environment after the intervention, and those in control groups were 1.41 times more likely to engage in ESB related to renewable energy and environment after the intervention (Table 4-5, next page).

I found evidence that the subject of students' classes (i.e., science, environmental science or earth science, math, language, technology studies, and agriculture) had an effect following the intervention. Specifically, science (i.e., biology, chemistry, and physics) and language students reported an increase in odds of BI towards ESB following the intervention. The students in science and language classes showed the greatest increase in odds of BI (3.44 for science and 3.49 for language; Table 4-5) for engaging in ESB following the intervention when compared to students in earth science and environmental science classes. Lastly, I found students that reported low to moderate levels of reported knowledge increased their odds to 1.48 times of engaging in ESB following the intervention.

4-4.4 School, State and Demographic effects

I found a significant change in post intervention BI odds for students that were enrolled in a private school compared to those in public or charter schools. Private school students were 0.33 times more likely to engage in ESB post- intervention; similar increases were not found for students in charter or public schools. However, no state level effects or effects related to suburban, urban, or rural schools following the intervention were found (Table 4-5).

Table 4-5. Predicted likelihood of behavioral intent of student towards ESB as reported through odds ratios at Post-intervention by social-demographic, attitudes, and beliefs

Predicting Variables	*B*	*Sig.*	*Odds Ratio*
(Intercept)	9.52	0.00	0.00
Treatment group*	**0.33**	**0.09**	**1.39**
Control group*	**0.34**	**0.09**	**1.41**
Public School	0.06	0.87	0.94
Private School**	**1.11**	**0.09**	**0.33**
Charter School	0a	.	1.00
Urban	0.14	0.75	0.87
Suburban	0.20	0.59	1.23
Rural	0a	.	1.00
State- NY	0.14	0.79	1.15
State- DE	0.26	0.66	1.29
State- MD	-0.16	0.74	0.85
State- OH	0.28	0.64	1.33
State- PA	0a	.	1.00
Male	0.24	0.23	1.27
Female	0a	.	1.00
White	0.13	0.69	0.88
Black	0.34	0.35	0.72
Asian	0.13	0.80	0.88
Hispanic	0.04	0.94	1.04
Multiracial	0a	.	1.00
Science**	**1.24**	**0.01**	**3.44**
Environmental Science	0.72	0.17	2.06
Math	0.36	0.73	1.44
Language**	**1.25**	**0.01**	**3.49**
Technology	0.66	0.26	1.94
Agriculture	0a	.	1.00
Past Behavior**	**0.11**	**0.01**	**1.11**
Low-Moderate Knowledge**	**0.39**	**0.06**	**1.48**
High Knowledge	0a	.	1.00
Normative Beliefs	0.02	0.47	0.98
Behavioral Beliefs**	**0.06**	**0.02**	**1.06**
Control Beliefs***	**0.15**	**0.00**	**1.16**
PBC**	**0.07**	**0.01**	**0.91**
Internal LOC	**0.02**	**0.00**	**1.93**
Norms***	**0.22**	**0.00**	**1.25**
Energy Attitudes	0.01	0.80	1.01
Anthropocentric Attitudes**	**0.12**	**0.01**	**1.13**
Ecocentric Attitudes**	**0.10**	**0.02**	**0.91**
Affective Attitudes***	**0.38**	**0.00**	**1.46**

p= < 0.10 level **=p < .05 level, ***= p < .01 level

I did not find any effect related to gender; the odds for male and female students to engage in ESB did not differ following the intervention. Similarly, race did not play a role in the odds following the intervention.

4-4.5 Effect of beliefs, norms, PBC, attitudes, past behavior, and attitudes(s)

PBC was a significant predictor of ESB BI in the post-intervention stage of the study. PBC decreased ESB slightly by 0.93 times following the intervention. While behavioral beliefs increased the odds of ESB by 1.06, internal LOC and control beliefs increased the odd by 1.93 and 1.16 respectively towards ESB in the post-intervention with students. Norms had a significant effect in the post-intervention stage, given that they increased the odds by 1.25 times for a students' likelihood towards ESB. In this study, past behavior during the post-intervention period increased the odds of engaging in ESB by 1.11 times in students.

Affective, ecocentric, and anthropocentric attitudes increased students' expressed ESB during the post-intervention stage. However, students' renewable energy attitudes were a poor predictor of ESB following the intervention. Lastly, affective attitudes increased the odds of BI by 1.46 times as compared to environment (0.91 times) and anthropocentric attitudes (1.13 times) for the post-intervention period.

4-5 Discussion

4-5.1 Effects of intervention and knowledge

I found no evidence that education altered students BI towards ESB: thus, the results do not support hypothesis 1 which stated that education played a role between the two groups (i.e., control and treatment groups). Similar null findings have been reported in a recent meta-analysis. Stern, Powell, and Hill (2014) reported that 12 studies that had utilized pre-post measures reported a lack of evidence that intervention had an effect. I believe this lack of effect is due to the nature of the study, that is, seldom EE studies measure a distinct control group to assess the net effect of an EE program. The other plausible explanation is indicated by the increase in BI that occurred across samples. The lack of effect in the current study was due to the increased odds towards BI that occurred in both groups in time 2. The odds of the control group increased 1.41 times, and that of the treatment group increased 1.39 times in favor of BI towards ESB, which suggested that there were other mechanisms at work besides education such as individual beliefs and attitudes. With my current findings, I add to a rather long list of mixed evidence on the specific role that education has towards BI and, ultimately, environmental behavior (Ballantyne and Packer 2009; Bogner1999; Dimopoulos; Paraskevopoulos, and Pantis 2008; Flowers, 2010; Johnson-Pynn and Johnson 2005; Knapp and Poff, 2001; Stern, Powell, and Ardoin 2008; Stern, Powell, and Ardoin 2010 and Zint, Kraemer, Northway, and Lim, 2002). The studies that have found an effect have measured short-term positive gains in cognitive outcomes through education when participant were surveyed immediately after the intervention and in some cases three months after (Dettman- Easler and Pease, 1996; Jordan, Hungerford, and Tomera, 1986; Knapp and Benton, 2006; Smith- Sebasto and Semrau, 2004). However, a longer-term assessment of meta-analysis of EE evaluations (Schneider and Cheslock, 2003) showed that engagement of student participants decreased substantially over time. My findings are consistent with these studies that show relatively small long-term effects.

Most surprisingly, I found that lower knowledge increased BI towards ESB following the intervention period. This finding seems to suggest that more education may not translate necessarily to an increase in BI towards ESB. Given that treatment groups were expected to receive information on renewable energy and the environment, having such information seems to be unrelated to creating the necessary elements that are required for students to make decisions about ESB (Ajzen, Joyce, Sheikh, and Cote, 2011). It is recognized widely that simply relaying knowledge is inadequate in fostering ESB (Gifford and Nilsson, 2014; Sterling, 2010; Stern, 2011). The current study did not assess in-depth content familiarity, but it simply asked students on self-reported knowledge levels following the intervention period in the treatment group. There are concerns about the validity of self-reported knowledge in this study. Self-reported knowledge may be inconsistent with what the students actually know. Assessing students on specific content questions in a future study could be used to explore this finding further.

4-5.2 Effect of subject

I found that students in science (i.e., biology, chemistry, and physics) and language classes were more likely to express BI towards ESB compared to students in environmental science and earth science classes. Separately, I also found that students in language classes had the greatest increase in odds of BI towards ESB. Language class students increase their odds 3.49 times towards ESB while science class students increased their odds 3.44 times towards ESB. These results seem to suggest that science and language classes were the most effective at teaching EE. It is interesting that students in environmental science and earth science classes did not have similar increases in odds compared to students in language or science classes. One would expect that environmental science and earth science are subject areas where there would be the greatest engagement with the topics of renewable energy and the environment. This may be an artifact of the type of students within science classes versus environmental science. High achieving students are often placed in science classes while lower achieving students take environmental science class, specifically AP environmental science to meet the AP requirement in many of these school districts. This particular finding suggests that more research needs to be conducted on why there are gaps between science classes (biology, chemistry, and physics) compared to environmental and earth sciences at these schools.

4-5.3 School, State and Demographic effects

Students from private schools showed a greater increase in BI towards ESB following the intervention than public or charter schools following the intervention. Students in private schools decreased their odds of BI 0.33 times towards ESB. I did not find that students in public or charter schools increased their BI following the intervention. Similar differences between private and public school students have been reported previously (Tuncer, Ertepinar, Tekkaya, and Sungur, 2005). However, because the majority of the sample in this study was public or charter school students, future studies should assess these findings with equivalent samples across school types. The composition of the student population (i.e., family background or prior achievement), competence of teachers, curriculum offered, quality of instruction, and the overall school climate all play a role in formation of views on the environment (Gamoran and Nystrand, 1994; Kuhlemeier, Bergh and Lagerweij, 1999). Future studies should assess whether income has an effect on BI and ESB, in addition to the above-mentioned factors. There may be differences in resources available between these schools that could explain the greater engagement of students at private schools.

I did not find any state level or rural, urban, or suburban effects that influenced BI towards ESB. Surprisingly, I also did not find a gender effect following the intervention, despite studies that have shown that female students were more engaged emotionally and, thus, showed an increased concern about environmental problems (Fliegenschnee and Schelakovsky, 1998; Lehmann, 1999). Females—including those of the age of my study participants--tend to have less environmental knowledge, but are more pro- environmental than males (Gifford and Sussman, 2012; Southwell, Murphy, DeWaters, and LeBaron, 2012). Future work on educational intervention should focus on the relationship between gender, education, and environmental attitudes. If males have lesser pro-environmental attitudes than females, and if education does indeed play a role in impacting pro-environmental attitudes, then we should see an increase in male students' pro-environmental attitudes on account of an educational intervention. Lastly, I found no evidence that race played a mediating role on students' BI towards ESB.

4-5.3 Effects of TPB, Beliefs, norms, PBC, and past behavior

I found evidence in support of hypothesis II: that pro-environmental attitudes, but not renewable energy attitudes, increased the likelihood of student BI. I also found some of the proposed explanatory variables within TPB, namely control beliefs, behavioral beliefs, PBC, norms, and attitudes predicted the likelihood of BI towards ESB in both control and treatment groups of students at post-intervention. Only normative beliefs were not significant predictors of BI towards ESB. Specifically, PBC, behavioral beliefs, control beliefs, and norms increased BI in students across groups by 0.93, 1.06, 1.16, 1.25 times, respectively ($p<.05$ for all).

These findings suggested that students are likely to engage in a given ESB if their behavioral belief is supported by their ability to perform the given behavior (i.e. control beliefs). Most interestingly, normative beliefs did not have a significant role after the intervention. This seemed to suggest that students are unaware of the existing norms may be for the measured ESB. I believe this is due to that fact that most of these topics are new and students have not discussed the behaviors with their peers. This observation is supported by the result that showed that norms had a significant effect in the post-intervention stage. At the post-intervention stage, I found norms influenced BI the most following the intervention. It may be that students were able to discuss the topic of renewable energy with their teachers, parents, and friends, given the increase in BI towards ESB that was accompanied with behavioral beliefs. The findings are consistent with a recent meta-analysis that indicates strong linkages between personal norms, PBC, and social norms and beliefs on BI (Klocner, 2013). There is substantial evidence that social norms affect ESB (Göckeritz, Schultz, Rendón, Cialdini, Goldstein, and Griskevicius, 2010; Nolan, Schultz, Cialdini, Goldstein, and Griskevicius, 2008; Schultz, 1999). This finding suggests that norms and behavioral beliefs play an important role in BI towards ESB in youth at K-12 institutions. More EE programs need to assess how specific norms can be activated that increases the ability of students to engage in ESB.

PBC, together with control beliefs, had a strong impact on intentions and, thereby, ESB. Control beliefs increased BI by 1.16 times, which suggested that, given the right conditions, students perceived that they were capable of engaging with renewable energy and environment. This is in line with recent work that also suggested the importance of creating the necessary conditions that can remove the obstacles that prevent students from engaging in ESB (De Leeuw, Valois, Ajzen, and Schmidt, 2015). Future work should examine more closely the role of PBC in encouraging students towards an increased BI of engaging in ESB, with or without education.

Past behavior was an effective predictor of BI. In this study, past behavior during the post-intervention period increased the odds of engaging in ESB by 1.11 times in students. This finding indicated that students that have undertaken learning about environment and renewable energy are more likely to continue doing so with or without teachers teaching them on those topics. Students that engaged in learning in the past (prior to the intervention) were 1.11 times more likely to continue seeking further information that can motivate them to undertake ESB. Studies have shown that ESB can be promoted by reminding individuals of their past pro-environmental actions (Cornelissen, Pandelaere, Warlop, and Dewitte, 2008; Van der Werff, Steg, and Keizer, 2014).

4-5.4 Effects of Attitudes (ecocentric, energy, anthropocentric, and affective)

The largest increase in odds was due to affective attitudes; BI for students increased 1.46 times in the presence of affective attitudes. Affective attitudes measured factors such as emotional affinity, empathy, and sympathy towards renewable energy and environment. I found partial support for hypothesis III that stated that student BI for students after learning about environment and renewable energy is impacted by four types of attitudes (i.e. ecocentric, anthropocentric, affective, and renewable energy attitudes). Hypothesis III was supported for all attitudes, except for renewable energy attitudes. I found that anthropocentric, affective, and ecocentic attitudes for all students (i.e., control or treatment) increased their BI towards ESB. Affective attitudes were the most significant predictor of students' intent to participate in ESB related to renewable energy and environment. But interestingly, renewable energy attitudes were not significant predictors of BI in students. I attribute the lack of effect with energy attitudes on the fact that students do not yet feel that they are able to make decisions that pertain to the choice of energy use in their lives. But they are able to exert a choice on their favorability or disfavorabilty via emotions. This is evident since the students showed positive and negative emotions that were related to renewable energy based on affective attitudes. Energy literacy surveys of students in K-12 schools have shown that affective scores were higher for students that indicated concern about energy-related issues and problems (DeWaters and Powers, 2011). These findings were consistent with earlier research (e.g., Bang, Ellinger, Hadjimarcou, and Traichal, 2000; Costanzo, Archer, Aronson, and Pettigrew, 1986; Farhar and Houston, 1996). Because I found that the greatest increase in odds were with affective attitudes, I suggest that future work should examine affective and cognitive beliefs more closely.

Anthropocentric attitudes were the second largest predictor of students' behavioral intent towards ESB. Anthropocentric attitudes value the utility function of nature as it pertains to human needs and want. I found that anthropocentric attitudes increased the odds 1.13 times and ecocentric attitudes increased the odds 0.91 times of increasing BI towards ESB. I found that ecocentric attitudes were distinct from energy, anthropocentric, and affective attitudes. This finding adds to ongoing research on multidimensionality of environmental attitudes (Schultz, 2001; Stern and Dietz, 1994). The correlation between anthropocentric and ecocentric attitude was low (0.27, $p<0.001$, Table 2). This provides further evidence that ecocentric and anthropocentric attitudes tend to occur together but are distinct (Dietz, Fitzgerald, and Schwom, 2005). Research from environmental psychology indicated that ESB was correlated strongly to an appreciation of nature (i.e., ecocentric attitudes) (Clayton, 2003; Mayer and Frantz, 2004). Thompson and Barton (1994) presented a generalized version of environmental attitudes as being rooted either in a concern for all living things (ecocentric) or a concern for humans (anthropocentric). Renewable energy (i.e., bioenergy) is a unique topic, because it can engage all three factors (egoistic, altruistic, and biospheric) independently or simultaneously.

Lastly, I found no evidence that attitudes were a significant predictor prior to the education intervention. Our findings are contrary to others that have shown that some ESB were impacted because of environmental education (Culen and Volk 2000; Volk and Cheak 2003), although some of their outcome measures (attitudes and skills) were mixed. These findings are in line with Smith-Sebasto and Cavern's study (2006), which indicated that neither pre-experience preparation nor post-experience follow-up, on their own, enhanced students' environmental attitudes.

4-6 Benefits and limitations of the current research method

A logit model was employed in this study, because of its ability to represent the complex aspects of the decisions made by individuals (a detailed discussion on the theoretical framework of the logit model can be found in McFadden, 1981). Given the constructed ordinal and binary nature of the dependent variable, the most appropriate estimation method to apply is ordered logistic regression. Both approaches, ordinary least squares (OLS) and logistic regressions have advantages. The results from the OLS regression model has been used in past empirical research on determinants of students' ability, especially because linear regression is often the tool used in much research on this topic. Dichotomization yields a more meaningful measure of the underlying relationship (Farrington and Loeber, 2000). It simplifies the presentation of results and produces meaningful findings that are easily understandable for a wider audience. The benefits of dichotomization in this respect could be outweighed by the disadvantage of losing information about differences between students on continuous variables such as BI. However, commonly used ordinary least-squares (OLS) multiple regression may be problematic with this type of research. It may often be implausible to argue that a one-point change in an explanatory variable causes a b-point change in the outcome variable across the whole range of values of the explanatory variable, which is BI. Given the dichotomization, it becomes plausible to report in terms of probability of a students' likelihood of undertaking ESB. Most importantly, unlike in an OLS, the values of the estimated parameters are adjusted iteratively until the maximum likelihood value for the estimated parameters is obtained (Hoetker, 2007). That is, maximum likelihood approaches try to find estimates of parameters that make the data that were actually observed "most likely." Therefore, I considered the dichotomous result to be more relevant. The general form of this model is such that BI was treated as a dichotomous latent variable that is then ordered into the two categories defined as likely and unlikely. Its interpretation was based on the odds ratio attached to each dummy variable. For example, using binomial logistic regression can communicate in very simple terms what the net increase in likelihood of the dependent variable (i.e. BI) is given that a student has certain characteristics, such as, being a male with anthropocentric and ecocentric attitudes.

Understanding how attitudes are predictive even without an intervention is relevant. There are, of course, many possibilities here. One example in our dataset might be a model where I hypothesize that teacher education affects motivation to teach renewable energy and environment, which in turn affects students' ability to learn and their attitude towards learning of renewable energy. This type of complex model with indirect and reciprocal effects can be modeled in structural equation modeling (SEM.) This would lead to a model that would be better able to interpret the complexity in such classroom-based, quasi-experimental studies.

4-7 Conclusions and future work

An intricate and a tenuous relationship between attitudes and behaviors exists, including in the environmental domain. I further add to this literature by showing that education itself is not an effective agent for changing environmental and affective attitudes toward renewable energy or the environment. The lack of evidence that attitudes played a significant role during pre-intervention suggested that attitudes of youth are not set as those of adults (Hogg and Vaughan, 2011). Prior work has shown that attitudes of children and teens grow stronger and more stable later in life (Crano and Prislin, 2008; Eagles and Demare, 1999; Lieflaender et al., 2013). Youth are more prone to changing their outlook, as is shown during post-intervention; all students in control and treatment groups held stable attitudes that were significant predictors of increasing BI to engage in ESB.

In summary, the BI of students was most responsive to external factors, such as being in a science class; when accompanied with PBC as well as affective, ecocentric, and anthropocentric attitudes, this combination predicted the greatest odds of a student to engage in ESB. Prior behavior models in environmental education (e.g., Hines et al., 1987; Marcinkowski, 1989; Hungerford and Volk, 1990; Stern, 2000) have all identified common determinants that included a sense of responsibility and locus of control as important determinants in engaging ESB. PBC is an important aspect within the affective strand of attitudes (Roth, 1992). I posit that mere exposure to a topic of interest on a regular basis could allow for this to occur. An increase in familiarity with renewable energy, simply by being exposed to it by taking a survey, may have played a role. For a student, more familiar the object becomes, the more favorable the attitude towards it. However, I state this with caution, because this study did not determine the exact level of engagement that could have occurred in the treatment group on the topic with students across multiples classes and schools. This work has determined the factors that influence the likelihood of a student to engage in ESB. Future studies should focus on understanding non-cognitive mechanisms that could allow attitudes to become predictive even with a lack of intervention (i.e., education).

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CHAPTER 5:

CONCLUSIONS AND FUTURE WORK

This dissertation examined whether education affected adult (i.e., teachers) and youth (i.e., students) behavioral intent towards renewable energy and the environment. The dissertation is comprised of three research articles, one of which engages survey methods. The remaining two articles discuss (respectively) the likelihood that teachers and students will engage in ESB post-education.

5-1 Summary findings

The first research article (chapter 2) contributed towards the use of technology in survey methods. I have demonstrated how ARS could be used as an effective tool to obtain survey responses that are statistically equivalent to traditional paper-and-pencil questionnaires. Further, I provided a framework by which ARS, if used, can allow for increased participation in classrooms, nature learning centers, and professional training programs. I was able to survey over 2,200 K-12 students and educators across five states. The ARS method could expand the reach of evaluation instruments and measure learning across formal and informal audiences.

The key finding from the teacher study (chapter 3) was that it may be shortsighted, and even counterproductive, for environmental and energy education to focus solely on environmentally-minded educators. I provided evidence that teachers that have pro-energy attitudes towards renewable energy are more likely to engage in teaching and cultivating broader

ESB than are environmentally-minded teachers. Furthermore, teachers that showed an increased Locus of Control (LOC) were more likely to teach topics that pertained to renewable energy, sustainability, and the environment.

The primary finding from the student study (chapter 4) was that students expressed increased behavioral intent regardless of whether they received education on renewable energy and the environment. More importantly, I showed that cognitive factors, such as being in advanced placement class in environmental sciences were less likely to increase BI of students towards ESB than non-cognitive factors, such as LOC. Lastly, I showed that Science and Language class students increased their BI towards ESB the most within the student study.

5-2 Conclusions and future work

The current research and outcomes point to four key areas where further research and K-12 educational policy development and implementation could occur:

5-2.1 Programs focused on STEM: Environmental and energy education, when they are focused and cross-disciplinary, can lend themselves to increasing higher-order skills, such as critical thinking, creative thinking, integrative thinking, and problem-solving for students (Disinger, 1993). The inherent strengths of environmental and energy education allow it to be a suitable vehicle for meeting educational reform goals of greater STEM education training[5.] Future research can rely on key attitudes that were identified in teachers and students to develop educational interventions that can focus less on education but more on providing tools and requiring renewable energy and environmental topics to be widely taught across all K-12

[5] The President's Council of Advisors on Science and Technology Executive Report Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future, available at: https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stemed-report.pdf

schools. This will foster ESB through STEM education.

Most importantly, teachers that are not pro-environmental in their attitudes are just as likely to teach renewable energy. Thus, the current focus on reaching only environmental educators within EE programs may be misplaced. It may be more effective for training programs to educate all teachers and students irrespective of their environmental attitudes or the classes that they teach. Furthermore, given the successful reduction of barriers that occurred in Science and Language classrooms for the students, future work must examine this more closely. I provided evidence of increased BI towards ESB of students in Science and English classrooms. There should be a rigorous and targeted attempt within EE training and K-12 school districts to engage teachers and students across the board and not just those in environmental studies. A discipline-specific approach has promulgated the teaching of concepts such as renewable energy, sustainability, and environment in the single subject or class of environmental science. Thus, emphasis should stress interdisciplinary teaching about the environment through STEM in a broader array of classes.

5.2-2 Behavioral approach: I argue for a paradigm shift to occur within curricula for environment and energy education. In our collective zeal to teach environment and renewable energy given the urgency of environmental problems, we may have lost sight on how learning actually occurs. This may have led some to argue that environmental education has failed to produce any meaningful, actionable behavior within the last 40 years of adoption (Saylan & Blumstein, 2011). I disagree with this claim, because students' attitudes did impact their BI towards ESB. Furthermore, many teachers did engage in teaching renewable energy, sustainability, and the environment. However, I do support the underlying notion that EE programs need to evolve.

Traditional models of environmental education focusing on imparting information must give way to more realistic psychological-foundational models that can enhance a participant's motivation and further enable them to put into practice what they have learned. I propose that a behavioral approach should be adopted. The behavioral approach should focus on skill set training that highlights the cognitive and the non-cognitive factors. Cognitive skills relate directly to learning, memory, and reasoning (Heckman, 2011), while non-cognitive skills relate to a range of factors such as teamwork, leadership skills, as well as self awareness and self control (Crawford, Johnson, Machin, and Vignoles, 2011). Cognitive and non-cognitive skills in aggregate will allow the proposed behavioral approach to succeed.

5.2-3 Cognitive behavioral approach: Social cognitive theories can explain how certain teachers were able to acquire and maintain certain ESB, while also providing the basis for intervention strategies. Social cognition is the study of how people view themselves and others (Fiske and Taylor, 1984). Social cognition is able to provide a framework for designing, implementing and evaluating EE programs. Students' and teachers' cognition as well as their motivation are joint functions of observer and situation. Both are essential to predicting behavior. The situation refers to the cognitive schemas of the environment that may affect a teachers or students behavior. Cognitions can help determine what a teacher will do, and which direction students' behavior will take given teachers motivations to teach. Motivation then predicts whether the behavior will occur at all, and if it does, to what degree (Fiske and Taylor, 2013). Because most observers are cognitive misers (i.e. limiting the capacity to process information) (Taylor 1981), they often take shortcuts to understand what is expected of them.

These shortcuts may have led to lack of implementation of the trained curriculum by the teachers in their classrooms. Teachers will rely on schemas—cognitive arrangements that represent knowledge about a concept or type of stimulus, including its attributes, and the relationship among those attributes (Fiske and Taylor, 1984)—to help facilitate behaviors. This process allows teachers to ignore certain traits that seem tangential to the abstract knowledge of targets. Put into context, when teachers were presented multiple attributes (e.g., the principal enforcing teaching of topics versus requiring students to prepare for standardized testing), the teachers were far more likely to be motivated to adhere to preparing students for standardized testing. Given that teachers were evaluated based on student performance in these tests they tend to do what is required as opposed to teaching topics that are not a core part of the curriculum.

In summary, a behavioral approach emphasizes cognitive and non-cognitive skills training (i.e. motivation, self-assessment, self-control, and LOC) for teachers, and non-cognitive assessment for students and EE programs. A non-cognitive assessment for EE programs means that researchers and practitioners ~~they~~ would have to add a behavioral measurement tool. Most EE programs measure change in knowledge right after the training and count program success based on number of teachers and students reached through the EE program. I have shown that internal LOC is effective in predicting the teaching behavior of teachers as well as the learning behavior within students. I propose that measures of PBC or self-control should be added that assess teachers' ability for teaching and students' capacity for learning. Understanding teachers' PBC will help agencies to understand the motivators underlying the teaching of their curriculum. Thus, EE programs should focus not just on content but training teachers on understanding agencies that can contextualize existing curriculum to incorporate newer topics such as renewable energy, environment, and sustainability. This can take the form of interpersonal (for example, communication, social skills, teamwork) processes and intrapersonal (for example, perseverance, self-esteem, self-control, self-motivation) processes training for practitioners.

5.2-4 ***Left-handed teaching and learning:*** I propose a left-handed teaching and learning approach. A left-handed teaching approach focuses on training teachers in the EE programs on non-cognitive, extracurricular skills such as the interpersonal and intrapersonal processes along with the standard classroom, teaching-related, cognitive skills. I have also shown that students were highly responsive to express BI for ESB when their affective and ecocentric attitudes were engaged. Thus, to be effective, environmental and energy education needs to adopt an affective approach. The need to focus on the affective domain is not new; it has long been identified as an important component that is necessary for learning in the EE context (Iozzi, 1989)

Left-handed learning would involve engaging social and emotional learning (SEL) that allows non-cognitive skills to be engaged in the students. For example, having students learn outside of classrooms has been shown to positively impact their affective attitudes and cognitive learning (Knapp, 1996; Sibthorp and Knapp, 1998; Storksdieck, 2006). SEL relies on the affective domain, and there is emerging evidence that SEL increases learning and performance, as well as individual behavior of students (Payton et al., 2008). Non-cognitive skills are more malleable than cognitive skills during the adolescent years (Carneiro, Crawford, and Goodman, 2007). Learning and social functioning are impacted greatly by the processes of emotions (Immordino-Yang and Damasio, 2007).

EE training programs that include only a cognitive component but not affective or non-cognitive components are less likely to succeed in enabling teachers to teach energy and environment or for students to learn and become engaged with ESB. Thus, left-handed learning and teaching will allow teachers and teacher training programs to incorporate learning experiences such as field trips and lesson plans that involved collaborative learning and exchanges between students that can engage students within their affective domain systematically.

5.2-5 Methods engagement: I propose that more innovative methods of engagement and assessment be researched and evaluated. I have shown that ARS can be used effectively to obtain large-scale data. EE programs will need to have abilities and tools to collect data, but they must also be able to so in a way that yields meaningful data. A recent review of EE programs found that EE program evaluation lacked the ability to verify which practices or programs produced a desired effect consistently (Stern, Powell, and Hill, 2014). ARS and other tools can be used effectively to obtain formative evaluations and summative evaluations, which could greatly address this need.

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APPENDIX A: A Survey Of Educator's Perceptions Of Attitudes Towards Renewable Energy Systems (RES)

A Survey Of Educator's Perceptions Of Attitudes Towards Renewable Energy Systems (RES)

Photo Credit: Erik Sandberg/Bernstein and Andriulli

Your Views On Current Renewable Energy Education And Energy Literacy

Cornell University
Department of Natural Resources
Human Dimensions Research Unit

Background to the Survey: This brief survey will result in:

1. An effective renewable energy related discussion and planning.

2. Allow for the integration between contemporary renewable energy technologies and their attributes within the wider school curriculum.

Survey Rationale:

Aim of the survey is to investigate the relationship between teachers' perceived information obtained on renewable energy, specifically bio-energy through a variety of sources and their perceptions, opinions, attitude and existing knowledge on various attributes of renewable energy.

Survey Study Sites:

This survey is being administered to educators from the following sites:

1. Cornell University, NY
2. Delaware State University, DE
3. University of Maryland Eastern Shore, MD
4. Ohio State University, OH
5. Pace University, NY
6. Boyce Thompson Institute, Cornell University, NY.

Your Participation:

You are invited to participate in this research study because you or your partner teacher was selected to be a part of **the Bioenergy and BioProducts Education Program at Cornell University**. A total of about 120 educators participated during the course (2012-13) of the study. Your participation will allow us to look at educators that have not participated in the program.

Note: Your identity and responses will be kept strictly confidential and the information you give us will never be associated with your name. Your participation in this survey is voluntary, but we sincerely hope you will take just a few minutes to answer our questions.

If you have any questions or concerns about this survey, please contact

Nirav Patel, Department of Natural Resources, Cornell University

607-339-6353 or nsp6@cornell.edumailto:nsp6@cornell.edu

1. Have you taught any of the following topics in the classroom?

(Check all that apply)

Climate Change	☐ NO	☐ YES
Renewable Energy Systems	☐ NO	☐ YES
Energy saving	☐ NO	☐ YES
Land Use Change	☐ NO	☐ YES
Carbon Emissions	☐ NO	☐ YES
Biomass Crops	☐ NO	☐ YES
Bioenergy	☐ NO	☐ YES
Bioproducts	☐ NO	☐ YES
Natural Gas	☐ NO	☐ YES
Wind Energy	☐ NO	☐ YES
Solar Energy	☐ NO	☐ YES
Tidal Energy	☐ NO	☐ YES
Hydroelectric Energy	☐ NO	☐ YES
Nuclear Energy	☐ NO	☐ YES

2. How much do you talk with your family about renewable energy at home?

Never Occasionally Sometimes Often

3. How much do you talk with your students about renewable energy?

Never Occasionally Sometimes Often

4. How much do you talk with your peers (i.e. teachers) about renewable energy?

Never Occasionally Sometimes Often

5. How much do you agree with the following?

a. Other teachers at my school think it is important that I teach about environmental issues.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

b. Parents think it is important we (teachers) teach about climate change at an early age.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

c. School administration thinks that there is enough external school support (i.e. workshops and teaching materials) to teach renewable energy.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

d. Other teachers at my school feel that engaging students at an early age is a way of reducing future energy needs.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

e. Other teachers at my school think that we should educate students about bio-energy for meeting our renewable energy demands.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

6. How do you feel about the following?

a. My family thinks that we should increase the use of bio-energy so that it lessens the effects of climate change.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

b. Other teachers at my school think that we should try to replace using fossil fuel use with biofuels.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

c. Other teachers at my school believe that we should use biomass as a major source of energy in the future.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

d. School administration feels that we should produce energy from biomass only if it's environmentally friendly.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

e. My community members should pay more such that the farmers are compensated for growing biomass for energy.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

f. My family needs to support politicians that support the research and development of bio-energy in the country.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

7. *Indicate HOW MUCH EACH STATEMENT DESCRIBES YOU by using the following scale: 1 (Does not describe me at all), 2 (Describes me a little), 3(Somewhat Describes me), 4(Describes me well), and 5 (Describes me very well)*

a) I take an active part in making school community a better place.

(Does not describe me at all) 1 2 3 4 5 (Describes me very well)

b) If I see any crime or atypical behavior at school, I report it.

(Does not describe me at all) 1 2 3 4 5 (Describes me very well)

c) In any teaching job I do, it is very important that I am helping other teachers and students.

(Does not describe me at all) 1 2 3 4 5 (Describes me very well)

d) With any task at school, I excel if I am working closely with other teachers.

(Does not describe me at all) 1 2 3 4 5 (Describes me very well)

e) I believe I should receive more recognition for the time and energy I spend on teaching.

(Does not describe me at all) 1 2 3 4 5 (Describes me very well)

f) I never hesitate to help others when they ask for it.

(Does not describe me at all) 1 2 3 4 5 (Describes me very well)

8. In order to be able to teach renewable energy education in the classroom, evaluate the following statements. (*Check one box for each row.)*

Statements	Unlikely Likely						
(I would be more likely to teach renewable	1	2	3	4	5	6	7

energy if …….)							
it educates students about environment and climate change issues.							
it is taught as a part of local/state green schools initiative.							
students enjoy learning about it.							
it teaches the scientific principles underpinning climate change.							
the principal and/or superintendent wants me to teach it.							
there is already a prepared curriculum and lesson plan on several topics							
if the students' seek more information on the topic							

9. Which of following would help you teach about renewable energy?

a. Support of principal

Not at all important 1 2 3 4 5 Very important

b. Support of other teachers

Not at all important 1 2 3 4 5 Very important

c. Additional educational programs on Renewable Energy Systems

Not at all important 1 2 3 4 5 Very important

d. Additional professional development and training

Not at all important 1 2 3 4 5 Very important

e. Structured Lesson Plans

Not at all important 1 2 3 4 5 Very important

f. Educational materials on bioenergy.

Not at all important 1 2 3 4 5 Very important

g. Exchange programs with other schools engaged in teaching renewable energy curriculum.

Not at all important 1 2 3 4 5 Very important

h. In-service training on RES.

Not at all important 1 2 3 4 5 Very important

i. Visual aids on renewable energy.

Not at all important 1 2 3 4 5 Very important

j. Students' asking questions on renewable energy

Not at all important 1 2 3 4 5 Very important

10. ***Most teachers that I know feel that…………***

a. students are not well-informed on renewable energy

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

b. laws protecting the natural environment should be made less strict in order to allow more energy to be produced.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

c. energy education should be an important part of every school's curriculum.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

11. *Most students that I know feel that…………*

a. personal energy use does not really make a difference to the energy problems that face our nation.
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

b. since the school pays for the electricity they should not worry about turning the lights off in the classroom.
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

12. Please rate between 1-5, how dependent in the future we should be for a particular type of energy source. (*Check one box for each row)*

Renewable Energy Type	***1 much less dependant***	***2 less dependant***	***3 about the same***	***4 should be more dependant***	***5 much more dependant***
All types of Renewable Energies					
Nuclear Energy					
Solar					
Wind					
Biomass					
Hydroelectric					
Tidal					
Natural Gas					
Oil					

13. Evaluate the following statements regarding renewable energy systems. (*Check one box for each row)*

How willing are you to …..	Very Unlikely				Very Likely
pay more taxes to support greater government support for renewable energy	1	2	3	4	5
pay more for utilities if it was from renewable energy.					
buy products from companies that use non-renewable energy.					
pay more for utilities only if it was coming from a local biomass (renewable) facility.					
educate yourself on renewable energy through workshops/programs.					
discuss about bio-energy with your peers.					
drive a car in the future that runs on bio-fuel.					

14. *Most people who are important to me think……*

a. We should make more of our electricity from renewable resources.
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

b. America should develop more ways of using renewable energy, even if it means that energy will cost more.
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

c. We don't have to worry about conserving energy, because new technologies will be developed to solve the energy problems for future generations.
Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

d. Efforts to develop renewable energy technologies are more important than efforts to find and develop new sources of fossil fuels.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Don't Know ☐

Background Information: *Renewable vs. Non-renewable resources*

Designing in a sustainable way begins with the simple understanding that some resources are available in a limited supply, and some resources are available in a limited, but renewable supply. Non-renewable, limited resources include things such as the amount of land, water, oil, coal, natural gas, and minerals in our accessible resource pool.

Renewable resources include things such as plant-based materials, sunlight, wind, geothermal and water-movement (hydro-based) energy. However, renewable resources are not available in a limitless supply over a short period of time, and are not always available "on demand".

Renewable Energy Systems (RES): The major renewable energy systems include photovoltaics (PVs) (or solar cells), solar thermal (electric and thermal), wind, bio- mass (plants, trees, algae), hydroelectric, ocean, and geothermal.[1]

[1] A Realizable Renewable Energy Future
John A. Turner, *et al. Science* 285, 687 (1999); DOI: 10.1126/science.285.5428.687

15. Below are some of the reasons mentioned for adopting RES, specifically- Biomass Energy Systems in order to meet the renewable energy demands of United States. Circle a number based 1-7 based on your level of agreement.

a. Promotes Energy Security and independence

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

b. Reduces Greenhouse Gases

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

c. Competes for land resource

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

d. Creates Green Jobs

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

e. Increases Local Sources of Energy

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

f. Minimizes Climate-Change Impacts

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

g. Creates Local Green Jobs

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

h. Minimizes carbon emissions for the society

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Now, please rank the top three reasons from the above list for adopting renewable energy.

Please write the letter of the top three reasons in the blanks below

Most important________

Second most important_________

Third_________

Please continue to evaluate these statements specifically related to **biomass energy and the usage of biomass crops** for energy uses.

i. Reduces soil erosion

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

j. Reduces herbicide and pesticides applications on farm

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

k. Increases wildlife habitat.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

l. Increases bio-diversity on the farms

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

(Note: For evaluating statements in Q16-20 below, renewable energy refers to energy from Solar, Wind, hydroelectric and/or Biomass.)

16. *When I use renewable energy, I feel…….*

unhappy 1 2 3 4 5 6 7 happy

17. I have complete control over whether or not to teach renewable energy

definitely false 1 2 3 4 5 6 7 definitely true

18. *To me using renewable energy is……*

a)	harmful	1	2	3	4	5	6	7	beneficial
b)	cheap	1	2	3	4	5	6	7	expensive
c)	inconvenient	1	2	3	4	5	6	7	convenient
d)	unpleasant	1	2	3	4	5	6	7	pleasant

19. Most of my students think that they should be educated further on renewable energy.definitely false 1 2 3 4 5 6 7 definitely true

20. I feel sad when people that I know do not value renewable energy

definitely false 1 2 3 4 5 6 7 definitely true

21. How important is each of the following to you ***(circle one number only per row)***:

Topic	Not at all Important	Not Very Important	Somewhat Important	Very Important
Poverty	1	2	3	4
Climate Change	1	2	3	4
Renewable Energy	1	2	3	4
Hunger	1	2	3	4
Obesity	1	2	3	4
Bullying	1	2	3	4

22. It upsets me to know that crops are used for energy production.

definitely false 1 2 3 4 5 6 7 definitely true

23. I enjoy seeing solar panels on roofs of buildings.

definitely false 1 2 3 4 5 6 7 definitely true

24. I get upset when I see windmills in my area.

definitely false 1 2 3 4 5 6 7 definitely true

25. How familiar are your **students'** with the following words and/or phrases?

(Circle One Number Per Row)

Words/Phrase	Not At All Familiar	Not Very Familiar	Somewhat Familiar	Very Familiar
Green Energy	1	2	3	4
Nuclear Energy	1	2	3	4
Renewable Energy	1	2	3	4
Biomass	1	2	3	4
Alternative Energy	1	2	3	4
Wind Energy	1	2	3	4
Solar Energy	1	2	3	4
Hydroelectric	1	2	3	4
Photovoltaic	1	2	3	4
Tidal Energy	1	2	3	4
Geothermal Energy	1	2	3	4
Climate Change	1	2	3	4

Land Use Change	1	2	3	4
Bioenergy	1	2	3	4
Recycling	1	2	3	4

26. A first consideration of any good political system is the protection of property rights.

Strongly disagree 1 2 3 4 5 Strongly agree

27. The best government is the one that governs the least.

Strongly disagree 1 2 3 4 5 Strongly agree

28. Decisions about renewable energy development are best left to the economic market.

Strongly disagree 1 2 3 4 5 Strongly agree

29. Applying more and better technology can solve most environmental problems.

Strongly disagree 1 2 3 4 5 Strongly agree

30. Plants and animals exist primarily to be used by humans.

Strongly disagree 1 2 3 4 5 Strongly agree

31. Environmental protection measures should be carried out even if this costs jobs

Strongly disagree 1 2 3 4 5 Strongly agree

32. Newspaper articles or TV-reports concerning environmental problems make me angry.

Strongly disagree 1 2 3 4 5 Strongly agree

33. It is still true that politicians do far too little for environmental protection.

Strongly disagree 1 2 3 4 5 Strongly agree

34. The balance of nature is very delicate and easily upset by human activities.

Strongly disagree 1 2 3 4 5 Strongly agree

35. Ecological rather than economic factors must guide our use of natural resources.

Strongly disagree 1 2 3 4 5 Strongly agree

36. We attach too much importance to economic measures in the well-being of our society.

Strongly disagree 1 2 3 4 5 Strongly agree

37. We are approaching the limit of the number of people the earth can support.

Strongly disagree 1 2 3 4 5 Strongly agree

38. When humans interfere with nature it often has disastrous consequences.

Strongly disagree 1 2 3 4 5 Strongly agree

39. Humans must live in harmony with nature in order to survive.

Strongly disagree 1 2 3 4 5 Strongly agree

40. There are limits to growth beyond which our industrialized society cannot expand.

Strongly disagree 1 2 3 4 5 Strongly agree

41. The Earth has plenty of natural resources if we just learn how to develop them.

Strongly disagree 1 2 3 4 5 Strongly agree

42. The so-called "ecological crisis" facing humankind has been greatly exaggerated.

Strongly disagree 1 2 3 4 5 Strongly agree

<u>Few Questions About Yourself</u>

1. In what school district do you currently teach? ___________________

2. In what year were you born? __________ (Year)

3. What is your gender? Male ☐ Female ☐

4. What is the highest level of education you have completed? (Check one.)

   Some college or other post-high school education ☐

   Completed a 4-year college degree ☐

   Graduate work or graduate degree ☐

PhD or advanced graduate degree ☐

5. What grade(s) do you currently teach? ________________

6. Have you recently been affected by severe weather events? Yes ☐ No ☐

7. Climate change made Hurricane Sandy worse.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

8. What topic(s) did you teach during 2012-13 academic year?_________________

9. Please circle your current level of knowledge about teaching renewable energy:

Not at all *Very little* *Somewhat knowledge* *Knowledgeable knowledgeable* *Extremely knowledgeable*

10. During the past year, how much of your class time has been spent talking/discussing renewable energy? ***(Circle the right choice)***

A	0 min	B	< 15min	C	15-60 min
D	1-2 hr	E	>2 hour		

11. What all topics have you taught at your school in the past? Please check and/or list

Science – Env. ☐

Other Science Topics ☐ Please specify _______________________

Technology ☐

Agriculture	☐
Language	☐
Government	☐
Economics	☐
Math	☐
Other topics	☐ Please specify__________________

Thank You So Much For Your Time!
Feel free to attach any comments you may have.

If you have any questions or concerns about this survey, please contact:

Nirav Patel, Department of Natural Resources, Cornell University
607-339-6353 or nsp6@cornell.edumailto:nsp6@cornell.edu

Educators' and Students' Perceptions of Attitudes towards Renewable Energy Systems (RES); **IRB Protocol No: 1105002254**

Cornell University IRB Approval Date: June 09, 2011, concurrence of exemption, June 10, 2012

APPENDIX B: Students Attitudes towards Renewable Energy Sources (RES)

ClickerID#________________________

Teacher's Name___________________________Class____________________________

Title: Students Attitudes towards Renewable Energy Sources (RES) **Cornell University**

Thank you for participating in this study about attitudes towards renewable energy. You are being asked questions about your personal opinion and preferences regarding renewable energy and learning. Please remember ***there are no right or wrong answers;*** therefore simply rate the scales (1-5) on your current state of opinion. We especially need and value your written comments for some questions because these comments enable **YOU** to justify or explain your thoughts on those topics, and enable us to understand why you chose to rate some of the item as you did. (*Please note that this study is anonymous and as such your responses will be kept anonymous during and after the study*.)

1. List the renewable energy sources that you have come across or studied.

2. What are the advantages of learning about renewable energy?

3. How important is each of the following to you ***(circle one number only per row)***:

Topic	Not at all Important	Not Very Important	Somewhat Important	Very Important
Poverty	1	2	3	4
Climate Change	1	2	3	4
Renewable Energy	1	2	3	4
Hunger	1	2	3	4
Obesity	1	2	3	4
Bullying	1	2	3	4

4. How familiar are you with the following words or phrases?

(Circle One Number Per Row)

Words/Phrase	Not At All Familiar	Not Very Familiar	Somewhat Familiar	Very Familiar
Green Energy	1	2	3	4
Nuclear Energy	1	2	3	4
Renewable Energy	1	2	3	4
Biomass	1	2	3	4
Alternative Energy	1	2	3	4
Wind Energy	1	2	3	4
Solar Energy	1	2	3	4
Hydroelectric	1	2	3	4
Photovoltaic	1	2	3	4
Tidal Energy	1	2	3	4
Geothermal Energy	1	2	3	4
Climate Change	1	2	3	4
Land Use Change	1	2	3	4
Bioenergy	1	2	3	4
Recycling	1	2	3	4

5. How often do you talk with your ***family*** about renewable energy at home?

Never Little Somewhat Often Very Often

6. How often do you talk with your ***teachers*** about renewable energy?

Never Little Somewhat Often Very Often

7. How often do you talk with other ***students*** about renewable energy?

Never Little Somewhat Often Very Often

8. Overall, learning about renewable energy has increased my interest on the topic.

Strongly disagree 1 2 3 4 5 Strongly agree

9. In the past year, how much have you learned about renewable energy?

(Not at all) 1 2 3 4 5 (Quite A Lot)

10. To me using renewable energy is……*(circle only one number per row):*

a)	harmful	1	2	3	4	5	beneficial
b)	expensive	1	2	3	4	5	cheap
c)	inconvenient	1	2	3	4	5	convenient
d)	difficult	1	2	3	4	5	easy

11. If or When I learn about renewable energy, I feel……. ***(circle only one number per row):***

a)	Sad	1	2	3	4	5	happy
b)	Optimistic	1	2	3	4	5	Pessimistic
c)	Unenthusiastic	1	2	3	4	5	Enthusiastic

12. I would like to learn about renewable energy.

Strongly disagree 1 2 3 4 5 Strongly agree

13. I would be more likely to learn about renewable energy if my friends want me to.

Strongly disagree 1 2 3 4 5 Strongly agree

14. To me, renewable energy is…(***circle only one number per row)***:

Costly	1	2	3	4	5	Not costly
Efficient	1	2	3	4	5	Inefficient
Limited	1	2	3	4	5	Unlimited
Safe	1	2	3	4	5	Dangerous
Reliable	1	2	3	4	5	Unreliable
Abundant	1	2	3	4	5	Scarce
Not able to solve energy problems	1	2	3	4	5	Able to solve energy problems
A bad way to address Climate change	1	2	3	4	5	A good way to address Climate change

15. My family should support politicians that encourage the research and development of renewable energy in the country.

Strongly disagree 1 2 3 4 5 Strongly agree

16. Learning about renewable energy is important in protecting the environment.

Strongly disagree 1 2 3 4 5 Strongly agree

17. How likely are you to ask your parents to use renewable energy even if it costs more?

Very Unlikely 1 2 3 4 5 Very likely

18. *Most people in my family think that…………*

(a) we do not have to worry about conserving energy, because new technologies will be developed to solve the energy problems for future generations.

Strongly disagree Disagree Agree Strongly agree

Don't know

(b) developing renewable energy technologies is more important than finding and developing new sources of fossil fuels.

Strongly disagree Disagree Agree Strongly agree

Don't know

19. What my *friends* think about renewable energy affects how I think of it.

Strongly disagree Disagree Agree Strongly agree

Don't know

20. What my *teachers* think about renewable energy affects how I think of it.

Strongly disagree Disagree Agree Strongly agree

Don't know

21. What my *family* thinks about renewable energy affects how I think of it.

Strongly disagree Disagree Agree Strongly agree

Don't know

22. I feel sad when people that I know do not use renewable energy

definitely false 1 2 3 4 5 definitely true

23. It upsets me to know that food crops are used for energy production.

definitely false 1 2 3 4 5 definitely true

24. I enjoy seeing solar panels on roofs of buildings.

definitely false 1 2 3 4 5 definitely true

25. I do not like seeing windmills in my area.

definitely false 1 2 3 4 5 definitely true

Background Information: *Renewable Energy Systems (RES): The major renewable energy systems include photovoltaics (PVs) (or solar cells), solar thermal (electric and thermal), wind, bio- mass (plants, trees, algae), hydroelectric, ocean, and geothermal.*

26. *How do you feel about being* ***dependent*** *on the following types of* ***Renewable Energy****?*

(*Circle only one number per row)*

Types Of Renewable Energies (RE)	**much less dependent**	**less dependent**	**about the same**	**should be more dependent**	**much more dependent**
(a) All types of RE	1	2	3	4	5
(b) Nuclear Energy	1	2	3	4	5
(c) Solar	1	2	3	4	5
(d) Wind	1	2	3	4	5
(e) Biomass	1	2	3	4	5
(f) Hydroelectric	1	2	3	4	5
(g) Natural Gas	1	2	3	4	5
(h) Oil	1	2	3	4	5

(i) Tidal energy	1	2	3	4	5

27. Teachers in my school think that an increase in the use of renewable energy will help reduce the problems of climate change.

Strongly disagree 1 2 3 4 5 Strongly agree

28. Since the school pays for electricity, we (students) should not worry about turning lights off in the classroom.

Strongly disagree 1 2 3 4 5 Strongly agree

29. Most people in my family think that we should make more of our electricity from renewable resources.

Strongly disagree 1 2 3 4 5 Strongly agree

30. Most people in my family think that America should develop more ways of using renewable energy, even if it means that energy would cost more.

Strongly disagree 1 2 3 4 5 Strongly agree

31. I think that renewable energy is very important in solving energy problems that face our country.

Strongly disagree 1 2 3 4 5 Strongly agree

32. Decisions about renewable energy development are best left to the private companies

Strongly disagree 1 2 3 4 5 Strongly agree

33. Most energy problems can be solved by applying more and better technology.

Strongly disagree 1 2 3 4 5 Strongly agree

34. Plants and animals exist primarily to be used by humans.

Strongly disagree 1 2 3 4 5 Strongly agree

35. Environmental protection measures should be carried out even if this costs jobs.

Strongly disagree 1 2 3 4 5 Strongly agree

36. Ecological rather than economic factors must guide our use of natural resources.

Strongly disagree 1 2 3 4 5 Strongly agree

37. We are approaching the limit of the number of people the earth can support.

Strongly disagree 1 2 3 4 5 Strongly agree

38. The Earth has plenty of natural resources if we just learn how to develop them.

Strongly disagree 1 2 3 4 5 Strongly agree

39. The so-called "ecological crisis" facing humankind has been greatly exaggerated.

Strongly disagree 1 2 3 4 5 Strongly agree

40. Have you studied any of the following topics in the classroom?

Topic	***(Check one box only for each topic)***		
Climate Change	☐ Not at all	☐ Somewhat	☐ A Lot
Renewable Energy Systems	☐ Not at all	☐ Somewhat	☐ A Lot
Energy saving	☐ Not at all	☐ Somewhat	☐ A Lot
Land Use Change	☐ Not at all	☐ Somewhat	☐ A Lot
Carbon Emissions	☐ Not at all	☐ Somewhat	☐ A Lot
Biomass Crops	☐ Not at all	☐ Somewhat	☐ A Lot

Bioenergy ☐ Not at all ☐ Somewhat ☐ A
Lot

Bioproducts ☐ Not at all ☐ Somewhat ☐ A
Lot

Natural Gas ☐ Not at all ☐ Somewhat ☐ A
Lot

Wind Energy ☐ Not at all ☐ Somewhat ☐ A
Lot

Solar Energy ☐ Not at all ☐ Somewhat ☐ A
Lot

Tidal Energy ☐ Not at all ☐ Somewhat ☐ A
Lot

Hydroelectric Energy ☐ Not at all ☐ Somewhat ☐ A
Lot

Nuclear Energy ☐ Not at all ☐ Somewhat ☐ A
Lot

41. How do you feel about the following reasons stated for using renewable energy in United
States? **(*Circle a number 1-5 below, based on your level of agreement*.)**

m. Promotes Energy Independence and Security

Strongly disagree 1 2 3 4 5 Strongly agree

(Energy independence and security relates to the goal of reducing the U.S imports of oil and other foreign sources of energy by producing energy within the country)

n. Reduces Greenhouse Gases

Strongly disagree 1 2 3 4 5 Strongly agree

(Greenhouse gases are typically-carbon dioxide, methane, nitrous oxide, and fluorinated gases that are thought to contribute to warming of the atmosphere and the ocean)

o. Competes for land resource

Strongly disagree 1 2 3 4 5 Strongly agree

(Land resource refers to natural resources that can be used from land that can be farmed.)

p. Creates Green Jobs

Strongly disagree 1 2 3 4 5 Strongly agree

(A green job is any job that benefits the environment or conserve natural resources.)

q. Increases Local Sources of Energy

Strongly disagree 1 2 3 4 5 Strongly agree

(Energy that can be found locally or that can be produced locally)

r. Minimizes Climate-Change Impacts

Strongly disagree 1 2 3 4 5 Strongly agree

(Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer.)

s. Minimizes carbon emissions for the society

Strongly disagree 1 2 3 4 5 Strongly agree

(Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle but it is also the primary greenhouse gas emitted through human and other natural activities. The main human activity that emits Carbon is the combustion of fossil fuels {coal, natural gas, and oil} for energy and transportation)

Now, please rank the top three reasons from the list (a-g above and previous page) for adopting renewable energy. Please write the letter of the top three reasons in the blanks below

Most important_______ Second most important________ Third________

42. What, if anything, have your teachers done this year to help you learn about renewable energy?

43. What could your teachers do to help you learn more about renewable energy?

44. How likely are you to do the following in the next month?(*circle one number only per row)*:

Description of the Activity	***Not at all Likely***	***Not very likely***	***Some-what likely***	***Very likely***
(a) Attend a local public meeting on renewable energy	1	2	3	4
(b) Volunteer with a local environmental group on energy	1	2	3	4
(c) Go talk with elected official on their renewable energy position.	1	2	3	4
(d) Join an online group on renewable energy outreach	1	2	3	4
(e) Start a renewable energy club at your school	1	2	3	4
(f) Ask teachers to include more topics on renewable energy	1	2	3	4
(g) Ask friends about renewable energy	1	2	3	4
(h) Post something online about renewable energy	1	2	3	4
(i) Talk to a family member about renewable energy	1	2	3	4

45. What activities worked well for you to learn about renewable energy?

46. What activities would you like to do in order to learn about renewable energy?

47. Please list anything that would make it more difficult for you to learn about renewable energy during this school year.

48. Are there any important points about renewable energy that have not been covered on this survey?

Feel free to attach any other comments below or separately.

Clicker ID#____________________

If you have any questions or concerns about this survey, please contact:
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THANK YOU VERY MUCH for your time and help!